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DISTRIBUTION AND MORTALITY OF CANVASBACKS BANDED IN NEW YORK[1]

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ABSTRACT

The canvasback has been declining in abundance in recent years. Records for ,361 birds banded in central New York during the winters of 1955 to 1958 provide nformation on the distribution and mortality of this species. Of the recoveries by unting, about 20 to 25 per cent have come from the states and provinces in which the irds that pass through New York breed (largely the Dakotas, Manitoba and Sas-atchewan), about 20 per cent from the Lake States and Ontario, and the remainder rom New York and the Middle Atlantic States.

Hunting seasons in 1955–56, 1956–57 and 1957–58 are considered comparable, nd about 6 per cent of the banded birds were reported taken the first season following hat in which they were banded. In 1958–59, when New York chose a split season xtending into early January and conditions for hunting diving ducks were especially avorable, the proportion of first-year recoveries nearly doubled. The rates of re-overy were also much greater for birds banded in prior years.

In winter concentrations in New York males were observed generally to outnumber emales. Distribution of the recovery records shows a tendency, noted by others, for emales to be taken more heavily during migration and males more heavily on the intering grounds. The data indicate a more rapid decline in abundance among emales than males, which seems attributable to factors other than hunting. The ossible relation of increasing age, a preponderance of males and the general status f the species is discussed. That failure of the annual increment could accentuate his preponderance and contribute to population decline is suggested.

In New York, as in every other area where it is available to the unner, the canvasback (*Aythya vallisneria*) rates high as a sporting bird nd table delicacy. However, relatively few New York gunners have ad an opportunity to hunt this species because it is a deep-water feeder, late season migrant and one of our least numerous waterfowl, and ecause it is primarily restricted to such waters as the larger Finger Lakes, ake Erie and Lake Ontario (Benson *et al.*, 1960). Likewise, few biolo-ists have had an opportunity to become familiar with its distribution

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and mortality in New York. In the early twenties A. A. Allen bande some canvasbacks at Ithaca (Schierbaum *et al.*, 1959), but large-scal banding awaited the development of a successful diving duck trap (Schier baum and Talmadge, 1954). It was also spurred by the results of aeria surveys (Benson *op. cit.*), agitation from deep-water duck hunters, and a apparent decline in the continental canvasback population. At presen over 10,000 canvasbacks have been banded in the State.

This paper supplements that of Benson (*op. cit.*) and discusses th available data pertaining to canvasbacks banded in New York. Th chief features considered are: (1) breeding and wintering areas, (2) fligh routes followed and distribution of harvest, (3) hunter-kill and mortality (4) sex differentials in kill by gunning, and (5) possible effects of varyin open seasons and bag limits. The information should aid in setting ope seasons and in formulating other management measures for the canva back in New York. It should also contribute to a better understandin

TABLE 1. CANVASBACKS BANDED IN NEW YORK DURING JANUARY, FEBRUARY AN MARCH FROM 1955 THROUGH 1958 AT FOUR UPSTATE STATIONS

Year and sex	Station				Total	Sex ratio
	Cayuga Lake	Seneca Lake	Canandaigua Lake	Dunkirk Harbor		
1955						
Male	112	365	183	425	1,085	79
Female	32	112	46	98	288	21
Total	144	477	229	523	1,373	..
1956						
Male	331	174	650	377	1,532	78
Female	101	79	146	95	421	22
Total	432	253	796	472	1,953	..
1957						
Male	368	334	1,543	531	2,776	75
Female	92	135	502	192	921	25
Total	460	469	2,045	723	3,697	..
1958						
Male	7	349	1,107	270	1,733	74
Female	2	129	428	46	605	26
Total	9	478	1,535	316	2,338	..
Total						
Male	818	1,222	3,483	1,603	7,126	76
Female	227	455	1,122	431	2,235	24
Total	1,045	1,677	4,605	2,034	9,361	..

of the implications of the work of Stewart *et al.* (1958) and Geis (1959) dealing with the canvasback on a continental basis.

The data used are derived from the records of 9,361 canvasbacks that were banded during January, February and March for the four years 1955 through 1958 (Table 1) and include recoveries received through June 1959. These birds were banded at four major upstate stations—Seneca Lake, Cayuga Lake, Canandaigua Lake and Dunkirk Harbor on Lake Erie. Other banding records, such as for canvasbacks banded on the breeding grounds and subsequently recovered in New York, are referred to where they furnish pertinent related information.

All winter-banded birds were considered adult since they had accomplished one leg of their annual migration, although in most years quite a large proportion were first-year or sub-adult individuals. For such birds, in contrast to waterfowl banded during the summer and fall, first-year hunting recoveries are, in essence, indirect recoveries since, after being banded, they must undergo a northward migration and breeding cycle before being subject to gunning. It should also be pointed out that the possibility of the entire banded sample having represented a static wintering population decreased during the later portion of the three-month period of banding because some birds were already migrating by that time. Furthermore, there was evidence of considerable "shuffling" between New York lakes, and even to Chesapeake Bay, throughout the winter.

The distribution of recoveries of canvasbacks banded in New York is summarized in Table 2. Recoveries made in the early part of the hunting season within the known breeding range of the canvasback only broadly illustrate the possible source of such birds. Rather, these data are of primary importance in showing where birds that winter in New York are harvested.

BREEDING AND WINTERING RANGES

Young that were banded before attaining flight are the most reliable source of information demonstrating origin. Table 3 presents the very limited amount of data available for canvasbacks banded on their breeding grounds and subsequently recovered in New York. All but one of these records were for flightless young, and the information, although admittedly meager, indicates the probable breeding areas of canvasbacks wintering in New York.

Using all the banding data available to the Fish and Wildlife Service, and drawing on indices from breeding ground surveys, Stewart *et al.* (*op. cit.*) estimated the harvest areas for birds from each of the major breeding areas. Their data suggest that South Dakota, North Dakota, Manitoba and Saskatchewan are the principal source of canvasbacks taken in New York, but they are not conclusive.

TABLE 2. DISTRIBUTION OF RECOVERIES BY HUNTING, THROUGH THE 1958–59 SEASON FOR CANVASBACKS BANDED IN NEW YORK FROM 1955 THROUGH 1958

Location §	Season						
	1955–56 Number	1956–57 Number	1957–58 Number	1955–56 to 1957–58		1958–59	
				Number	Per cent	Number	Per cen
Saskatchewan...	..	2	7	9	1.5	4	0.5
Manitoba.....	5	6	17	28	4.7	18	2.2
North Dakota..	2	11	20	33	5.6	4	0.5
South Dakota...	2	2	8	12	2.0	8	1.0
Minnesota.....	5	18	36	59	10.0	22	2.8
Wisconsin.....	7	10	14	31	5.2	10	1.2
Illinois.....	1	2	5	8	1.3	1	0.1
Michigan.....	7	5	13	25	4.2	10	1.2
Ontario.....	9	11	19	39	6.6	24	3.0
Ohio.....	2	4	3	9	1.5	3	0.4
New York.....	42	42	82	166	28.0	563	69.9
New Jersey....	..	..	4	4	0.7	10	1.2
Pennsylvania...	2	6	6	14	2.4	3	0.4
Maryland.....	13	41	60	114	19.2	88	10.9
Virginia.....	..	7	8	15	2.5	10	1.2
Other†.....	4	5	18	27	4.6	28	3.5
Total.....	101	172	320	593	100.0	806	100.0

* Note, for New York, the difference in percentage between 1958–59 and the p ceding years.

§ Provinces and states listed in rough progression from the breeding grounds wintering grounds.

† Includes recoveries from related areas as follows:
Iowa, Kansas, Missouri, Oklahoma, Texas and Louisiana—16
Indiana, Kentucky, Tennessee and Alabama—16
Delaware, North Carolina, South Carolina and Florida—11
Quebec, Connecticut and Rhode Island—7
California and Oregon—5

For many years waterfowlers have been inclined to consider t canvasbacks wintering in New York as essentially a terminal and consta population. A study of retrapping records (Table 4), however, reveal a constant shuffle and trading between the upstate lakes. Recover made at Dunkirk tended to be in March and probably represented mov ment that was the start of spring migration. Interchanges betwe Canandaigua, Seneca and Cayuga Lakes occurred during all months the trapping period and might best be termed a restless shuffle. individual stations, some birds proved nearly sedentary and were f quently retaken throughout the winter. Others, apparently representi small flocks traveling together, would be present for a week or so and th disappear completely, only to reappear again several weeks later.

TABLE 3. CANVASBACKS BANDED ON THEIR BREEDING GROUNDS AND SUBSEQUENTLY RECOVERED IN NEW YORK DURING 1955 THROUGH 1958

Location of breeding grounds	Age of birds banded	
	Adult	Flightless young
Manitoba	1	2
Saskatchewan	..	4
North Dakota	..	1
South Dakota	..	1
Minnesota	..	5
Total	1	13

TABLE 4. CANVASBACKS BANDED AND RETRAPPED DURING THE SAME SEASON AT NEW YORK STATIONS DURING THE YEARS 1956 THROUGH 1958

Station where banded *	Station where recovered §				Total
	Cayuga Lake	Seneca Lake	Canandaigua Lake	Dunkirk Harbor	
Cayuga Lake	..	0	9	0	9
Seneca Lake	16	..	34	4	54
Canandaigua Lake	1	35	..	23	59
Dunkirk Harbor	1	3	12	..	16
Total	18	38	55	27	138

* Banding stations arranged east to west.
§ Birds retaken at station where they were banded are not included.

An appraisal of winter movement as shown by hunter-kill recoveries and retrapping records indicates a dynamic situation. The territory frequented does not appear to have been limited to New York waters but included wintering areas to the south; birds banded in New York were retrapped the same year in New Jersey and on Chesapeake Bay. Hunter-kill records showed that up to 30 per cent of canvasbacks banded in New York during the winter were taken in areas farther south during subsequent hunting seasons. The proportion taken in different years varied (Table 5) suggesting variations, most likely due to weather (Bellrose, 1957), in the numbers that move through to the Chesapeake region on the fall migration or that remain in the northcentral and Lake States.

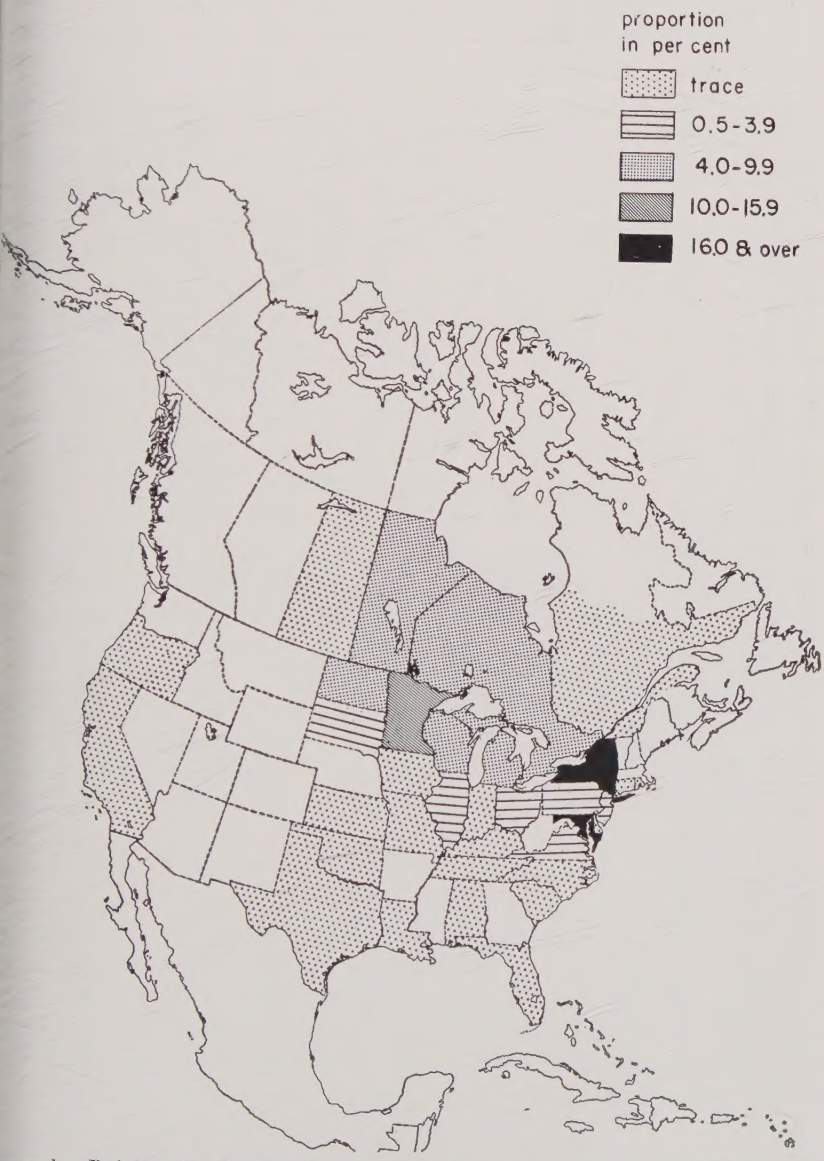
TABLE 5. REGIONAL DISTRIBUTION OF RECOVERIES BY HUNTING, THROUGH THE 1958–59 SEASON, FOR CANVASBACKS BANDED IN NEW YORK FROM 1955 THROUGH 1958*

Season	Location											
	North and west of New York				New York				South and east of New York			
	Number			Per-cent	Number			Per-cent	Number			Per-cent
	Male	Fe-male	Total		Male	Fe-male	Total		Male	Fe-male	Total	
1955–56	29	9	38	39.2	30	12	42	43.3	13	4	17	17.5
1956–57	46	21	67	40.1	29	13	42	25.1	46	12	58	34.7
1957–58	95	44	139	46.0	58	24	82	27.2	56	25	81	26.8
Sub-total	170	74	244	43.1	117	49	166	29.3	115	41	156	27.6
Per cent	69.7	30.3	100.0	.....	70.5	29.5	100.0	.....	73.7	26.3	100.0	.....
1958–59	72	29	101	13.0	465	98	563	72.4	74	40	114	14.6
Per cent	71.3	28.7	100.0	.....	82.6	17.4	100.0	.....	64.9	35.1	100.0	.....

* Does not include the miscellaneous records cited in the footnote to Table 2.

MIGRATION ROUTE AND DISTRIBUTION OF HARVEST

The migration route of canvasbacks banded in New York, as determined by the distribution of the harvest, has been clearly described by Stewart *et al.* (*op. cit.*). It is further illustrated by Table 2 and Figures 1 and 2. As a result of mixing and regrouping on the breeding grounds,



gure 1. Relative distribution of recoveries by hunting, through the 1957–58 season, for canvasbacks banded in New York from 1955 through 1957.

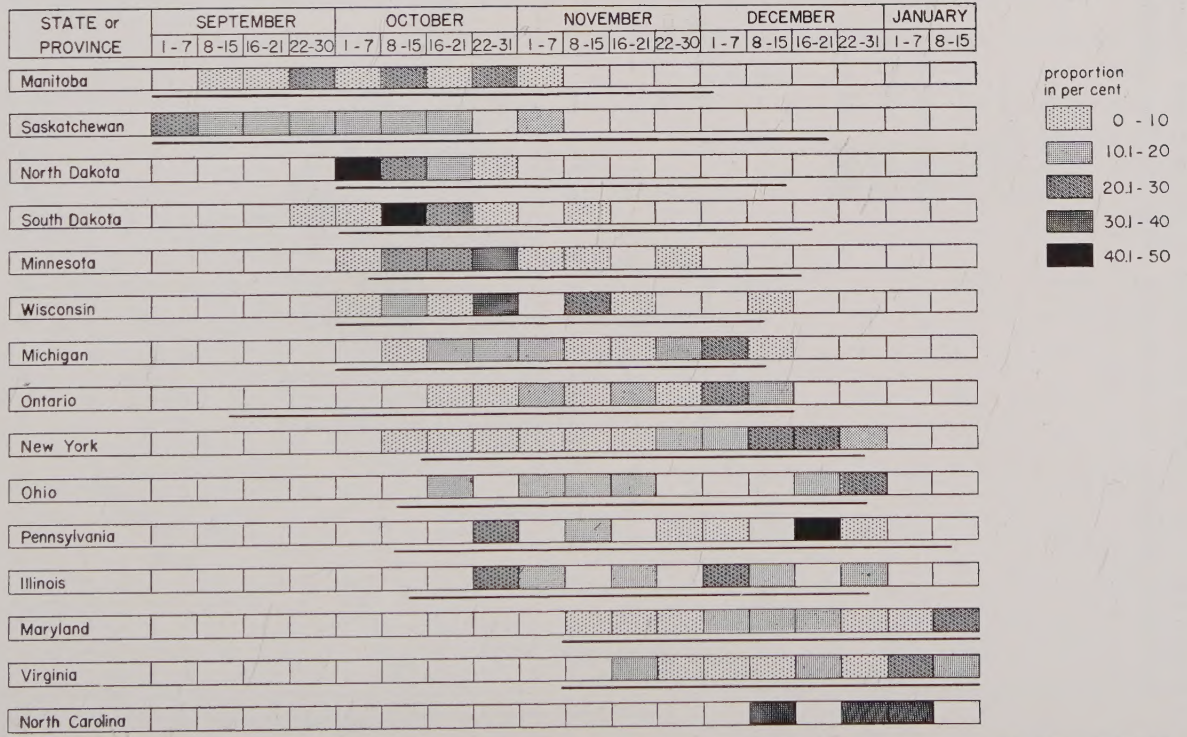


Figure 2. Weekly distribution of harvest of canvasbacks banded in New York, for the seasons of 1955–56 to 1957–58 in various states and provinces (the latter listed in rough progression from breeding grounds to wintering grounds). In New York the drop in proportion for the last week was mainly due to season not including

a few of these birds travel south in the Mississippi and Central flyways, and an occasional recovery in the Pacific flyway indicates even wider dispersal. But, as a whole, most of them travel a fairly constant route from the breeding grounds through the Dakotas, Minnesota and the Lake States to New York and the Middle Atlantic States.

For canvasbacks banded in New York the proportion harvested from year to year was variable, influenced probably by weather, the time of the gunning season, and possibly other factors. While the degree of harvest varied, the distribution of the hunter kill remained fairly constant with certain states and provinces supplying the bulk of the recoveries (Table 2). The reasons apparently lie in differences in habitat, type of hunting, time of the open season and canvasback availability. Minnesota, Wisconsin and Michigan are located strategically on the "canvasback flyway". They afford large, open bodies of water favored by this species, and their seasons extend from the early flush of migration nearly to freeze-up. The spread of the harvest is illustrated in Figure 2. For birds banded in New York, an average of roughly 30 per cent were taken in the State, but this often varied sharply. In Maryland, one of the greatest sources of recoveries of birds banded in New York, shooting is done on a terminal wintering population, and the number taken seems to have been largely dependent on what happened in New York and further north during the same hunting season (Table 5). A high take of birds in New York and/or other northern states and provinces apparently produced a corresponding low take in Maryland. Again, the cause of variability of hunter success in the several regions of heavy canvasback kill is not definitely known, but it is suspected to relate closely to weather and associated migration patterns. Generally, however, it may be expected that in most years 20 to 25 per cent of the harvest of canvasbacks banded in New York during the winter will be made in the same states and provinces that produced them, about 20 per cent will occur in the Lake States and Ontario, while the remainder will be divided, slightly in favor of New York, between this State and the Middle Atlantic States.

MORTALITY

Data presented in Table 6 indicate that recovery rates by hunting during the first year after banding were relatively consistent for canvasbacks banded in 1955, 1956 and 1957; the average was 6.5 per cent. Records for birds banded in 1958 show a much higher rate due to the split season selected by New York in 1958–59. The recovery rate was also high during this same gunning season for birds banded prior to 1958.

For comparison, data for 1,855 black ducks banded in the winters of 1958 and 1959 on Long Island are presented in Table 7. These black ducks were banded during January, February and March and underwent the same type of breeding and migration cycle as the canvasbacks before

TABLE 6. PROGRESSIVE RATES OF RECOVERY BY HUNTING FOR CANVASBACKS BANDED IN NEW YORK FROM 1955 THROUGH 1958

Sex	Number banded	Recoveries according to hunting season subsequent to banding							
		1		2		3		4	
		Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Birds banded in 1955									
Male	1,085	75	6.9	33	3.0	22	2.0	71	6.5
Female	288	26	9.0	10	3.5	4	1.4	6	2.1
Total	1,373	101	7.4	43	3.1	26	1.9	77	5.6
Birds banded in 1956									
Male	1,532	91	5.9	55	3.6	106	6.9	....	....
Female	421	38	9.0	15	3.6	19	4.5	....	....
Total	1,953	129	6.6	70	3.6	125	6.4	....	....
Birds banded in 1957									
Male	2,776	149	5.4	245	8.8	....	....	....	....
Female	921	75	8.1	78	8.5	....	....	....	....
Total	3,697	224	6.1	323	8.7	....	....	....	....
Birds banded in 1958									
Male	1,733	210	12.1	....	....	....	....	....	....
Female	605	71	11.7	....	....	....	....	....	....
Total	2,338	281	12.0	....	....	....	....	....	....

being subjected to gunning. The first-year recovery rates of 8.4 per cent in 1958 and 3.8 per cent in 1959 appear comparable to those for the canvasback as given in Table 6. The difference could merely reflect local variations in flight pattern and hunting pressure, as well as the length of the open season and the daily bag both of which were curtailed in 1959.

However, other factors are also involved. Geis (*op. cit.*) pointed out that first-year recoveries for canvasbacks banded as flightless young may run as high as 22 per cent and first-year mortality rates as high as 77 per cent. In contrast, in other work in New York (unpublished),

Table 7. First-Year Recoveries by Hunting for Black Ducks Banded on Long Island During January, February and March of 1958 and 1959

Year	Sex	Number banded	Recoveries		Relative vulnerability
			Number	Per cent	
1958	Male	408	35	8.6	1.1
	Female	225	18	8.0	1.0
1959	Male	673	29	4.3	1.3
	Female	549	18	3.3	1.0
Total	Male	1,081	64	5.9	1.3
	Female	774	36	4.7	1.0

records for free-flying immature black ducks banded at Perch River in 1953 and 1954 showed first-year recoveries of only 10.4 per cent, and their first-year mortality rate was 58 per cent. Foley and Schierbaum (1957) showed immature black ducks to be about 1.4 times as vulnerable to gunning as adults. They also found males to be about 1.3 times as vulnerable as females, a ratio similar to that for the black ducks banded on Long Island (Table 7). On the contrary, among canvasbacks the rate of return from gunning was usually higher for females than for males during the first year, about equal the second year and lower in succeeding year (Table 6). These points strongly suggest substantial mortality from causes other than hunting and indicate female canvasbacks to be much more susceptible to external forces than female black ducks.

SEX DIFFERENTIALS

Related to differential mortality between the sexes is the actual sex ratio. Observers generally are in agreement that males regularly outnumber females to a substantial degree in fall and winter flocks of canvasbacks. Unfortunately, the banding ratio may not necessarily represent the true sex ratio because at times trapping may not take a random sample of the birds present. In the present study, the proportion of males among the birds banded during the four winters averaged 76 per cent (Table 1). However, what appears to have been an annual decrease in the proportion was in reality a result of what occurred at the Canandaigua Lake station only where nearly 50 per cent of the canvasbacks included in this study were banded.

Geis (*op. cit.*) summarized the sex ratios recorded during banding in other states and provinces. These ranged from 66 per cent males in Louisiana and 65 per cent in Maryland to 76 per cent in Michigan and 77 per cent in New York. The data for Maryland and New York were for the same years, while the others were for earlier periods. These data

suggest that more northern wintering flocks may have had a higher pro portion of males, but they also bear out the conclusion that the males regardless of the area, exceeded the females.

Seasonal

In Table 8 the recoveries by hunting for the period from Septembe through November are compared with those for December and January These data show that during both portions of the season males were take more frequently than females. This was true both in years when th total harvest was about equally distributed between the early and lat portions and in 1958–59 when the major harvest occurred during the lat portion. The data also show that the proportion of females was con sistently greater among the birds taken during the early portion of th season than among those taken later. These findings generally paralle those of Stewart *et al.* (*op. cit.*) who suggested there may be a highe vulnerability among females during migration and among males on th wintering grounds. Moreover, when the data are considered in relatio to the proportions of the two sexes as originally banded (an average o 76 males to 24 females as shown in Table 1), it is evident that, during th early portion of the season, females were taken at a greater rate than mal in terms of the supply. Later the two sexes were taken in more nearl the same ratio as that in which they were banded. Thus, despite the outnumbering females among the canvasbacks taken by hunters, male were seldom taken in excess of the relative numbers present.

Table 8. Comparison of Recoveries by Hunting During the Early and La Portions of the Open Season for Canvasbacks Banded in New Yor from 1955 through 1958 *

Season	September through November				December and January			
	Male		Female		Male		Female	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
1955–56	34	73.9	12	26.1	41	74.5	14	25.5
1956–57	64	67.4	31	32.6	60	77.9	17	22.1
1957–58	108	68.4	50	31.6	107	72.3	41	27.7
Sub-total	206	68.9	93	31.1	208	74.3	72	25.7
1958–59	65	69.1	29	30.9	437	77.1	130	22.9

* No recovery records are included that did not show the month taken, and the fiv recoveries from the Pacific flyway are omitted.

Annual

Hunting recoveries for canvasbacks banded in New York have shown (Table 6 and Figure 3) a higher first-year rate of harvest for females than for males during comparable seasons. During the second year following banding the rates for males and females appear to have been nearly equal, but in subsequent years the rate for males exceeded that for females. Comparison of the ratio between the rates of recovery by hunting for the two sexes during the first year following banding (as given in Table 6) shows that the proportion of females to males increased from 1.3 in 1955 to 1.5 in 1956 and 1957 (Table 9). In 1958–59, when the harvest in New York comprised 83 per cent males (Table 5), the proportion for the flyway dropped to 1.0 suggesting an equal or slightly greater vulnerability

Figure 3. Sex ratios among canvas backs taken by hunting compared with those for the corresponding groups at time of banding.

of males in that year. This was the only instance in which first-year recoveries for males and females were in approximately the same ratio as that in which the two sexes had been banded. Of interest, also, is the indication that the greater relative take of males during this last season was more pronounced among the birds banded in 1958 than among those banded earlier.

Data for the 1958–59 season did not represent the same type of canvasback harvest as those for the three preceding seasons. While this season produced an abnormally high take in New York, it resulted in a larger and therefore more reliable sample of the proportions of the sexes being harvested. For birds in their fourth hunting season subsequent to banding, the proportions recorded in 1958–59 were 92 per cent males and 8 per cent females (Table 10). The reliability of this sample is supported by the fact that the sex ratios recorded in 1958–59 for birds

Table 9. Relative Vulnerability to Gunning of Female Canvasbacks Banded in New York *

Year banded	Hunting season subsequent to banding			
	1	2	3	4
1955	1.3	1.2	0.7	0.3
1956	1.5	1.0	0.7	...
1957	1.5	1.0	...	...
1958	1.0	...	...	...

* Based on rates of recovery given in Table 6; figures represent number of females per male.

Table 10. Progressive Sex Ratios (in per cent) for Recoveries by Hunting for Canvasbacks Banded in New York

Season	Hunting season subsequent to banding							
	1		2		3		4	
	Male	Female	Male	Female	Male	Female	Male	Female
1955–56	74	26	..	..	..	..	..	..
1956–57	71	29	77	23	..	..	..	..
1957–58	67	33	79	21	85	15	..	..
1958–59	75	25	76	24	85	15	92	8

in their second or third year after banding were similar to the corresponding ratios for birds taken in 1956–57 and 1957–58. There is, therefore, no reason to presume that the sex ratio for the canvasbacks that represented season 4 among those taken in the 1958–59 season was out of proportion, even though the absolute numbers killed were abnormally high. These data emphasize the more rapid mortality among females than among males during the period following the first season after banding, as shown by the relative rates of recovery during seasons 3 and 4 given in Table 6.

Thus, it seems that the more rapid decline in the rate of harvest of females was the result of a sharper drop in availability among them than among males. Although first-season recoveries were higher for females than for males, this cannot completely account for their lower availability in subsequent years. Considering the progressive sex ratios for recoveries by hunting during the first four years after banding, it would appear that at the end of five seasons virtually all the remaining canvasbacks would be males.

Geographical

Separation of hunting recoveries according to region where taken (Table 5) shows that, for the three seasons that are assumed to have been comparable, the sex ratios in the northern areas and in New York were similar (70 males to 30 females). Farther south the proportion of females was slightly lower (74 males to 26 females). Most of the southern returns were from Maryland. However, considering the ratio in which the birds were originally banded (76 males to 24 females), these data indicate that females were taken at a higher rate than males throughout the flyway, particularly in the northern areas and New York. Only in New York in 1958–59 did males appear to be taken in a higher ratio than females (83 to 17).

Effect of Hunting Regulations

During the first three years (1955–56 to 1957–58) hunting regulations were roughly comparable. The framework for the open season, as established by the U. S. Fish and Wildlife Service, was October 1—January 15 and the daily bag limit of four ducks was uniform throughout the Central, Mississippi and Atlantic flyways with no other restrictions regarding the take of canvasbacks. In each year New York chose a continuous season opening in mid-October. In 1958–59, due to their steadily decreasing numbers, the daily bag limit for canvasbacks and redheads was reduced to two in the aggregate. In this year, also, New York elected to have a split season upstate, the first period of which was October 16—November 25, and the second, December 27 through January 8, 1959.

Although annual recoveries of canvasbacks by hunting in New York had varied as much as 18 per cent in prior years (Table 5), this in part could be traced to the percentage recovered in certain states and provinces through which these birds had passed before arriving in New York and was also reflected by the corresponding take in Maryland and other states to the south. In short, this appeared to be a "normal" variation in hunting success in response to weather conditions and other factors resulting in varying migration patterns. In 1958–59, however, both the number of recoveries and their distribution was sharply altered. Over the preceding three years the proportion of the canvasbacks that were banded in New York and also taken in New York had averaged nearly 30 per cent, but in 1958–59 it jumped to 72 per cent, virtually all of which were taken in the later segment of the split season. Because of the high take in New York the total first-year rate of recovery for birds banded in 1958 rose to 12.0 per cent in contrast to an average of 6.5 per cent for the three previous seasons (Table 6).

The reasons for this increased kill in New York are difficult to evaluate. The late segment of the season occurred during extremely cold weather and was accompanied by the freeze-up of many areas usually frequented by canvasbacks. As a result, the birds were concentrated on the relatively few open water areas left. In addition, the late season excited great interest among diving duck hunters and consequently hunter concentrations were high. Behavior of the birds also played a leading role in hunter success. Canvasbacks particularly were very active, flying in small groups and decoying well. In addition, the unusual interest among sportsmen in waterfowl hunting that winter may have resulted in an increased rate of band reporting.

It is also difficult to assess the effect of the lower bag limit in 1958–59. The data indicate a significant decrease in take in the northcentral and Lake States where the bag limit was reduced and no difference in the Prairie Provinces and Ontario where the more restrictive regulations were not in effect (Table 11). However, they indicate no change in take in the states to the south of New York where the same bag limit reduction was in force.

Although the more obvious results of the late-season shooting in New York have been discussed, certain aspects merit further analysis. As shown in Table 6, the first-year recovery rate during this season was 12.0 per cent or nearly double the average for the preceding three years. The total number of banded canvasbacks reported taken in 1958–59 was 806 and represented four groups banded in different years. The recovery rates (two to four years after banding) for the first three of these groups approached or surpassed the corresponding first-year recovery rates. In every case, also, the rate exceeded that of the preceding year. Where a normal or constant kill pattern would have indicated a recovery

Table 11. Comparison of Rates of Recovery (in per cent) by Hunting in Different Regions During the First Season After Banding for Canvasbacks Banded in New York

Region	Seasons of 1955–56, 1956–57 and 1957–58	Season of 1958–59	Significance §
Saskatchewan, Manitoba	0.41	0.34	
North Dakota, South Dakota, Minnesota	1.22	.047	*
Wisconsin, Michigan, Illinois	0.73	0.34	*
Ontario	0.50	0.43	
New York	1.68	8.00	*
Ohio, Pennsylvania, New Jersey	0.30	0.30	
Maryland, Virginia	1.31	1.58	

§ Asterisk (*) indicates significant difference at 5 per cent level of probability.

ate of approximately 1 per cent for the birds banded in 1955, the 1958–59 ate was 5.6 per cent. Thus it seems evident that the increased kill pplied to all groups of banded birds.

Because, in the East, hunting conditions for diving ducks are best n late fall and winter, the number of canvasbacks taken in December and January far exceeds that taken earlier in the fall. For the birds banded n New York, 68 per cent of the total harvest occurred during these months. Of interest, however, is the sex distribution of the kill early and late in he season (Table 8). Apparently the reduction in bag limit had no mportant effect on this distribution, although the proportion of males aken was slightly higher during the December–January period. This igher kill of males was directly associated with the harvest in New York.

States and provinces to the north and west of New York showed no ppreciable change in the sex ratio among the birds taken in 1958–59 ompared with the average for the preceding three years (Table 5). The narked change occurred in New York and southward. Whereas in revious years the proportion of males among the birds taken in New ork averaged 70 per cent, in 1958–59 it was 83 per cent. At the same ime, recoveries from states to the south (primarily Maryland) showed a eduction from 74 per cent males in earlier years to 65 per cent in 1958–59. he reason for the higher kill of males in New York appears to parallel

that given by Stewart *et al.* (*op. cit.*), who concluded that females tend to be killed more heavily on the breeding grounds and early in migration while males are killed to a greater degree on the wintering grounds. The data from New York substantiate this tendency, although they are not statistically conclusive. During the earlier years the waterfowl season in this State closed in mid-December when canvasbacks were still migrating. In 1958–59 the season did not close until January 8 and overlapped the beginning of the period when wintering populations had become established, if such a condition can be attributed to canvasbacks in New York.

DISCUSSION

The records for canvasbacks banded in New York have been presented and various relationships have been discussed. Differences between the sexes with respect to various correlations have been demonstrated. A further aspect is the relation between the sex ratio and the general status of the species. Of what significance are the disproportionate numbers of males in certain species of waterfowl that do not seem to be thriving? This is not an original question—many biologists have considered it. Hochbaum (1944, p. 153) stated

> "The demonstrated failure of abundance to save a species, and the evidence pointing to an excess of males as a symptom of population decline, should lead us still to view the status of some of our ducks solemnly. The Redhead, Canvasback and Ruddy Duck, despite large wintering concentrations in some regions, show numbers considerably less than 'great abundance,' and all are top-heavy with drakes.
>
> "What can we do about these unbalanced ratios? The answer is 'not much' until we determine the causes of the distortion. Here lies one of the most important and still largely unexplored fields of waterfowl biology."

Hochbaum (*op. cit.*) reported that canvasbacks are hatched in a 50:50 ratio, while Geis (*op. cit.*) calculated a mortality rate of 77 per cent among juveniles between late summer and the end of the first hunting season. Using recoveries by hunting from Manitoba, Hochbaum also reported a greater rate of loss for females than males among birds of the year. For adults, the data recorded in this study demonstrate a more rapid decline in abundance among females than among males. Thus the higher the average age of a population during the fall and winter the greater would be the proportion of males in it. By the same token failure of the annual increment, especially for several successive years would accentuate this preponderance of males. Further work needs to be done to determine the importance of this relationship and its bearing on canvasback management.

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GROWTH, MOVEMENTS AND SURVIVAL OF SMALLMOUTH BASS (*MICROPTERUS DOLOMIEUI*) IN ONEIDA LAKE, NEW YORK[1]

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ABSTRACT

Smallmouth bass were tagged and released prior to the fishing season from 19
to 1958. Most recoveries of tagged bass were made near the tagging site, indicati
localized populations. When bass were moved from the netting site to distant rele
points the majority of the displaced bass returned to their home area.

Growth of bass in Oneida Lake compared favorably with that of bass in oth
northern lakes. Bass in the Constantia population average 9.8 inches at age II
12.3 at age IV, 13.5 at age V and 14.7 at age VI. Small but consistent differences
growth rate were observed among three Oneida Lake bass populations which w
studied.

Geometric mean survival for age V to X bass, based on a catch curve, was 0.
Annual survival rates estimated from tag returns in successive years were 0.48 in 19
0.42 in 1956 and 0.82 in 1957. For these three years minimum rates of exploitati
were 0.18, 0.21 and 0.05. Assuming the instantaneous natural mortality rate (q)
constant, it is shown that $i = C\,(u'\frac{i}{a}) + q$ may yield an approximate estimate c
from paired values of total mortality (a) and minimum rates of exploitation (u').
instantaneous natural mortality rate of 0.08 was calculated for bass in Oneida Lak

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Smallmouth bass rank second only to pikeperch as the most soug
game fish in Oneida Lake. Tagging of adult smallmouth bass was beg
in 1954 by New York State Conservation Department biologists and c
tinued from 1956 to 1958 by the Warm Water Fisheries Investigati
Unit at Cornell University. The five-year program was initiated
assess the current status of the smallmouth bass population and to provi
a basis for evaluating future changes in fishing regulations. In this pa
growth, movements and survival of several populations of bass in Onei
Lake are described.

Oneida Lake in central New York has an area of 51,000 acres and
about 20 miles long and 5 miles wide. The maximum depth is 55 f
with 25 per cent of the lake area under 12 feet deep. Shoreline expo
to wave action consists predominately of rubble and boulders with
transition to sand or mud at depths over 12 feet. In several areas
tensive rocky shoals occur over a mile from shore. Earlier publicati

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-17
Biologists of the New York State Conservation Department, particularly A.
Petty and James P. Galligan, initiated the bass-tagging program in 1954, conduc
all field work in 1954 and 1955 and made available tag-return information
both years. Personnel of the Oneida Fish Hatchery collected most of the
tagged during the study and the cooperation of Foreman Frank Youmans fa
tated processing these fish. Charles Taylor, fishery technician of the Cor
University Biological Field Station, assisted in all phases of the field work beginn
in 1956. Cooperation of Oneida Lake anglers in reporting recoveries of tag
fish made a major contribution to the study. The writer is indebted to Profe
D. A. Webster and Dr. A. W. Eipper for review and comment on the manuscr

igure 1. Map of Oneida Lake showing three zones used in summarizing smallmouth bass tag returns.

have described the bottom fauna, distribution of aquatic plants, and some limnological features of the lake (Baker, 1916; 1918). Adams and Hankinson (1928) published the results of an extensive survey and discussed the management of most food and game species.

PROCEDURE

In May, bass are collected by personnel of the Oneida Fish Hatchery in trapnets set at several locations within a mile of Constantia. The fish are transferred to hatchery ponds for spawning and removed from the ponds in early June. In the years 1954 through 1958, measurements and scale samples were taken, and tags were placed on bass immediately before they were returned to the lake.

Small numbers of bass collected by shocking were tagged at Shackelton Point and Muskrat Bay in April and May 1957. In May of 1958 trapnets were used to collect bass at Shackelton Point on the south shore, and on Shackelton Shoals in the center of the lake.

All bass were tagged with a monel metal strap, 2¼ x $\frac{1}{8}$ inch in size, supplied by Salt Lake Stamp Company. The tag loosely encircled the mandible. Tags were shortened to fit 10- to 12-inch bass, the smallest size tagged. This type of jaw tag caused little or no irritation of tissue and showed no tendency to wear through the mandible in the case of 103 tagged bass recovered in nets at Constantia from 1956 through 1958.

Scales were removed from an area below the lateral line just posterior to the end of the extended pectoral fin. Plastic impressions were made from scales and examined on a micro-projector with a magnification of 27×.

FINDINGS

Data on growth, movements and survival are presented under separate headings.

Growth

Scale markings were distinct and the validity of the annulus as a ye mark appears established by:

(1) The numerical abundance of the 1948, 1949 and 1952 ye classes in samples taken at Constantia in successive yea (Table 1).

(2) Generally good agreement between observed and calculat lengths at the end of various years of life (compare Tables and 2).

(3) Agreement between year classes as to good or poor growth certain calendar years (see Table 5).

Smallmouth bass held in spawning ponds at the Oneida hatche had rarely formed an annulus by mid-June when the fish were release but annulus formation occurs earlier in bass which remain in the lake. a sample of 110 bass collected from the lake between June 16 and 2 1957, an annulus had formed on the scales of 97 per cent of the II+ a III+ fish, 55 per cent of the IV+ fish and 15 per cent of the older fi

The relationship between scale radius and body length was det mined from measurements of 577 scales from fish 3.0 to 19 inches length. Individual measurements were divided into suitable leng class intervals, and a regression table of total length on magnified sc image was made by a method described by Goulden (1952). Tests significance for linear regression and deviation from linearity were ma for the body-scale relationship. Deviations from linearity were n significant at the 5 per cent level. Calculated lengths were determi from the regression equation:

Total length = 1.62 inches + 1.1038 × anterior radius (millimete where magnification of the scale image was 27×.

Observed lengths of smallmouth bass in the Constantia spawn population are shown in Table 1 and calculated lengths in Table Under the existing 10-inch minimum size limit these bass were be recruited into the fishery during their third and fourth growing seaso Growth in this population was substantially better than that reported Cayuga Lake (Webster, 1954), eastern Lake Ontario (Stone *et al.*, 19 and Manitoulin Island in Lake Huron (Fry and Watt, 1957), but it v slightly slower than that of bass in Lake Erie (Doan, 1940).

Calculated growth data for the Constantia spawning populati showed Lee's phenomenon of apparent change in growth rate (Table The phenomenon was noticeable only in age groups III and IV. Webs (1954) observed that the more rapidly growing smallmouth bass in a y class mature first. It is, therefore, suggested that the phenomenon this case resulted from sampling age groups which were not fully matu

Year of capture	Length statistic	Age III	IV	V	VI	VII	VIII	IX	X
1954	Mean length	11.4	12.2	13.5	14.4	15.4	16.4	18.8	17.2
	Standard error	....	0.27	0.10	0.10	0.24	0.42	....	....
	Number specimens	1	7	52	52	10	3	1	1
1955	Mean length	11.8	12.7	13.4	14.1	15.3	....	....	17.9
	Standard error	0.13	0.18	0.41	0.22	0.17	....	....	....
	Number specimens	17	10	3	7	10	....	....	1
1956	Mean length	11.0	13.3	14.1	15.2	15.7	15.4	17.4	....
	Standard error	....	0.05	0.13	0.12	0.18	0.15	....	....
	Number specimens	1	195	15	8	15	15	1	....
1957	Mean length	11.0	11.7	13.5	14.8	16.1	16.3	16.4	16.8
	Standard error	....	0.07	0.06	0.18	0.57	0.70	0.17	....
	Number specimens	2	58	165	8	3	3	8	2
1958	Mean length	11.4	12.7	13.5	14.8	16.0	16.7	16.5	17.1
	Standard error	0.12	0.08	0.10	0.07	0.26	0.01	0.53	0.32
	Number specimens	5	56	44	83	7	3	4	9

Table 2. Mean Calculated Total Length in Inches for Smallmouth Bass in Oneida Lake at the End of Each Year of Life

Specimens*		Annulus									
Age at capture	Number in sample	1	2	3	4	5	6	7	8	9	10
III	26	4.2	7.9	11.2	....	....	....	....	....	....	....
IV	326	3.9	7.2	10.3	12.9	....	....	....	....	....	....
V	279	4.2	6.7	9.5	11.9	13.5	....	....	....	....	....
VI	158	3.6	6.6	9.4	12.1	13.5	14.6	....	....	....	....
VII	45	3.5	6.4	9.4	11.8	13.6	14.5	15.6	....	....	....
VIII	24	3.6	6.9	9.8	12.2	14.2	15.1	15.9	16.5	....	....
IX	14	3.6	6.9	9.3	12.0	13.7	14.7	15.7	16.2	16.6	....
X	13	3.3	6.4	9.0	11.4	13.2	14.3	15.4	16.3	16.7	17.1
Grand mean		3.9	6.9	9.8	12.3	13.5	14.7	15.7	16.4	16.7	17.1
Number specimens		885	885	885	859	533	254	96	51	27	13

*Netted near Constantia in May, 1954–1958.

Observed lengths of bass netted at Shackelton Shoals were lower at each age than those of bass netted at Shackelton Point and Constantia in 1958 (Table 3). Calculated lengths of samples from these three populations (Table 4) indicate growth of bass at Shackelton Shoals was consistently slower throughout life than that in populations at Shackelton Point and Constantia. Stone *et al.* (1951) and Fry and Watt (1957) observed similar differences in growth rates of smallmouth bass populations separated by only a few miles of open water.

Fluctuations in annual growth of bass at Constantia have occurred since 1950. Each column of Table 5 shows the increment for different years of life in the same calendar year and each diagonal row the growth history of a year class. Age III fish appearing in Table 2 are not included in Table 5 since these were apparently exceptionally fast-growing individuals. All year classes appear to have been influenced by annual fluctuations in growth rate. Growth increments for the first to eighth years of life were large in 1952, 1954 and 1955, and relatively small in 1951, 1953 and 1956. The same patterns of annual fluctuations in growth are apparent in scales of pikeperch from Oneida Lake (Forney, 1959).

The 1948, 1949 and 1952 year classes predominated in the spawning populations sampled at Constantia from 1954 to 1957 (Table 1). In 1954, age V and VI bass, representing the 1948 and 1949 year classes, respectively, comprised 82 per cent of the trapnet catch. The 1952 year class, represented by age IV in 1956 and age V in 1957, comprised 74 per cent of the spawning population in 1956 and 65 per cent in 1957. Although dominance of the 1952 year class was still apparent in the catch at Constantia in 1958, their dominance was less pronounced in samples from Shackelton Point and Shackelton Shoals (Table 4). Fry and Watt (1957) found similar variation in year class strength among three populations in bays bordering Manitoulin Island in Lake Huron.

Movements

Bass were netted, tagged and released within a mile of Constantia in 1954, 1956, 1957 and 1958. In 1955, bass netted at Constantia were released at Lakeport, Sylvan Beach, Cleveland and Walnut Point. Additional bass caught by shocking or trapnetting at Shackelton Shoals and Shackelton Point in April and May in 1957 and 1958 were tagged and released in the area where they were taken. Tag returns were obtained through voluntary reports of anglers. To facilitate analysis of the data, the lake has been divided into three zones as shown in Figure 1.

First-year recoveries of bass released at Constantia totaled 342, for which 219 tag returns were accompanied by adequate data on the location of capture. About 63 per cent of the recoveries were made in Zone 1, within 2½ miles of Constantia. There is no evidence that bass released

Table 3. Mean Observed Total Length in Inches for Smallmouth Bass Netted at Three Locations in Oneida Lake in May 1958

Location	Age										
	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Constantia											
Mean	11.4	12.7	13.5	14.8	16.0	16.7	16.5	17.1	....	....	....
Number specimens	5	56	44	83	7	3	4	9	....	....	....
Standard error	0.12	0.08	0.10	0.07	0.26	0.01	0.53	0.32	....	....	....
Shackelton Point											
Mean	11.0	12.8	13.7	15.0	15.4	15.9	16.5	16.6	16.5	....	....
Number specimens	21	45	41	45	6	4	3	17	2	....	....
Standard error	0.16	0.10	0.11	0.11	0.12	0.45	0.15	0.18	0.10	....	....
Shackelton Shoals											
Mean	10.3	12.0	13.1	14.5	14.8	15.6	16.1	16.5	16.7	17.2	17.8
Number specimens	9	28	102	62	4	3	12	21	9	1	1
Standard error	0.29	0.10	0.06	0.08	0.44	0.35	0.13	0.16	0.17	....	....

Location	Age												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Constantia	3.9 (885)	6.9 (885)	9.8 (885)	12.3 (859)	13.5 (533)	14.7 (254)	15.7 (96)	16.4 (51)	16.7 (27)	17.1 (13)	....	....	....
Shackelton Shoals	3.2 (252)	6.0 (252)	9.3 (252)	11.4 (242)	13.1 (215)	14.4 (113)	14.9 (51)	15.6 (47)	16.0 (44)	16.4 (32)	16.8 (11)	17.4 (2)	17.8 (1)
Shackelton Point	3.7 (184)	7.0 (184)	9.9 (184)	12.1 (163)	13.5 (118)	14.5 (77)	15.2 (32)	15.7 (26)	16.2 (22)	16.4 (19)	16.5 (2)	....	....

*Figures in parentheses are numbers of fish used to compute averages.

Table 5. Mean Annual Increment in Length in Inches for Smallmouth Bass in Oneida Lake Netted Near Constantia According to Calendar Year *

Age	Calendar year													
	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
I	3.6	4.5	3.7	3.4	3.6	3.9	3.5	3.4	3.9	3.4	3.7	...	...	...
II	...	3.0	3.6	2.9	3.2	3.3	2.5	2.5	3.4	3.0	3.0	4.0	...	...
III	...	...	3.1	3.2	3.2	3.4	2.3	2.8	3.2	2.9	3.2	3.5	2.1	...
IV	...	...	...	2.1	2.4	2.8	2.0	2.3	3.0	2.5	2.6	2.8	1.6	2.9
V	...	...	...	...	2.1	1.4	2.0	1.5	2.1	1.5	2.0	1.9	1.2	2.2
VI	...	...	...	...	...	0.8	0.8	0.8	1.3	0.9	1.2	1.6	0.6	1.4
VII	...	...	...	...	...	...	0.9	0.8	0.7	0.6	1.0	0.8	0.3	1.1
VIII	...	...	...	...	...	...	...	0.7	1.2	0.3	0.7	0.7	0.3	0.9
IX	...	...	...	...	...	...	...	...	0.5	0.5	...	0.9	0.2	0.7
X	...	...	...	...	...	...	...	...	...	0.4	0.2	...	0.2	0.5

* Each diagonal row gives the growth history of a year class.

t Constantia disperse after the first year. The number of first-year ecoveries of bass released in 1954 was compared with the combined econd to fifth-year recoveries in each zone (Table 6, part A). A chi-quare test of homogeneity was not significant, indicating that relative umbers recovered from the three zones were similar. The same con-lusion is reached by comparing first-year recoveries of bass released in 956 with the recoveries for bass tagged in 1954 which were at large two ears (Table 6, part B).

In 1955, bass taken at Constantia were released at points 5 to 15 iles away. The distribution of first-year recaptures in 1955 differed gnificantly (chi-square = 43.50) from first-year recaptures of bass eleased at Constantia in other years (Table 6, part C). Bass released t Sylvan Beach, Walnut Point, Cleveland, and Lakeport traveled an verage straight-line distance of 4.2 to 7.7 miles before capture. The verage distance traveled by bass released at Constantia in 1954 was 2.4 iles. It is apparent from a comparison of the distribution of first-year ecoveries of bass released in 1956 with second-year recoveries of bass eleased in 1955 that increased movements of the latter group resulted in majority of the survivors returning to the Constantia area by 1956 Table 6, part D). This is also indicated by the differences in distri-ution between first-year and subsequent recoveries for bass tagged in 955 (Table 6, part E).

Bass tagged and released at Shackelton Point, Shackelton Shoals, Muskrat Bay and Lakeport in 1957 and 1958 showed little movement. bout 80 per cent of the 67 recoveries reported by anglers were made ithin 1½ miles of the tagging site. Remarkably little exchange occurred etween the Constantia and Shackelton Shoals populations, which are eparated by 3 miles of open water. Although both areas are important ass fishing grounds, just three bass tagged at Constantia were recovered t Shackelton Shoals and a single bass tagged at Shackelton Shoals was aught near Constantia.

The pattern of tag returns from smallmouth bass in Oneida Lake emonstrates the presence of localized groups of bass with little tendency o disperse during summer. Similar conclusions were drawn from mallmouth bass tagging in eastern Lake Ontario (Stone *et al.*, 1951) and Lake Huron (Fry and Watt, 1957).

ATES OF EXPLOITATION AND SURVIVAL

The effect of the mandible strap tag on survival, behavior and ulnerability of bass has not been adequately investigated. During this udy there was no evidence of mortality during or immediately following gging. Examination of tagged bass at large for several years suggests at loss of tags through erosion of the mandible seldom occurs. Vulner-

Table 6. Distribution by Zone (see Figure 1) of Tag Recoveries for Bass fr Constantia Population Released from 1954 through 1958

Year tagged or recovered	Zone 1	Zone 2	Zone 3	Chi-square test of homogeneity
(A) First-year and subsequent-year recoveries of bass released in 1954				
1954	68	21	14	1.85
1955–1958	57	24	19	
(B) 1956 recoveries of bass tagged in 1954 and in 1956				
1956	50	19	15	1.00
1954	28	9	5	
(C) First-year recoveries of bass released in 1955 and combined 1954 and 1956–1958 first-year recoveries				
1955	21	21	40	43.50*
1954 and 1956–1958	141	43	35	
(D) 1956 recoveries of bass released in 1955 and 1956				
1955	27	9	14	1.90
1956	50	19	15	
(E) First-year and subsequent-year recoveries of bass tagged in 1955				
1955	21	21	40	10.24*
1956–1958	31	9	20	

* Significant at 0.01 probability level.

ability of tagged bass to angling appeared to decrease slightly as the length increased (Table 7), but differences in the proportions recovere for four size classes were not significant (chi-square = 4.37). Howeve Fraser (1955) observed a decided increase in vulnerability to angling wi increase in age in the smallmouth bass fishery of South Bay in La Huron. Fraser's conclusions were based on a comparison of the a distribution of the catch and the virtual population.

Bass were tagged 2 to 3 weeks before the angling season opened July 1. Recoveries in each 2-week period of the season for bass releas the same year were roughly proportional to those for bass released preceding years (Table 8). This suggests that transferring bass spawning ponds prior to release in the lake had no marked effect on the vulnerability to angling.

TABLE 7. FIRST-YEAR ANGLING RECOVERIES OF SMALLMOUTH BASS IN FOUR LENGTH CATEGORIES FOR BASS TAGGED AND RELEASED AT CONSTANTIA, 1954–1958

Group	Total length (inches) at tagging				Total
	10.0–11.9	12.0–13.9	14.0–15.9	16.0 & over	
eleased	255	1,138	814	177	2,384
ecovered	46	162	111	18	337
roportion recovered	0.18	0.14	0.14	0.10	0.14

TABLE 8. SEASONAL DISTRIBUTION OF FIRST-YEAR AND SUBSEQUENT-YEAR TAG RECOVERIES REPORTED BY ANGLERS FOR BASS RELEASED AT CONSTANTIA, 1954–1958

Year recovered	Numbers of recoveries						Total
	July 1–15	July 16–31	Aug. 1–15	Aug. 16–31	Sept. 1–15	Sept. 16–Nov. 15	
irst	36	46	44	32	27	21	206
econd to fifth	43	30	30	26	26	28	183
Total	79	76	74	58	53	49	389

MINIMUM RATES OF EXPLOITATION Numbers and percentages of ass, tagged from 1954 through 1958 and recovered by anglers in subequent fishing seasons following release, are shown in Table 9. The rastic decline in exploitation rate from 21.4 per cent in 1956 to 4.6 per ent in 1957 parallelled a similar decline in exploitation of pikeperch from 7.5 per cent in 1956 to 4.2 per cent in 1957 (Forney, 1959). The change exploitation rate between 1956 and 1957 apparently reflected a change vulnerability of bass to angling since only a moderate decrease in fishing ressure was observed.[2] Growth increments of age IV and older bass Table 3) were exceptionally small in 1956 and large in 1957, suggesting at food availability may in part explain the change in the angling ılnerability.

Tag recoveries from 181 bass tagged at Shackelton Point in 1958 taled nine, giving an exploitation rate of 0.05. In the same year nglers returned 25 of 271 bass released at Shackelton Shoals prior to

[2] Total boat rentals for the months of July through September at three Oneida Lake boat liveries were 4,599 in 1956 and 3,024 in 1957, suggesting a decrease of 33 per cent in fishing pressure.

Table 9. Number of Tags Reported by Anglers from Smallmouth Bass Nett at Constantia and Released at the Beginning of the Fishing Seas 1954–1958

Year released	Number released	Recoveries in subsequent fishing seasons *					
		1st	2nd	3rd	4th	5th	6th
1954.....	828	114 (13.8)	49 (5.9)	54 (6.5)	8 (1.0)	8 (1.0)	5 (0.6
1955.....	514	94 (18.3)	57 (11.1)	7 (1.4)	4 (0.8)	4 (0.8)	...
1956.....	499	107 (21.4)	10 (2.0)	9 (1.8)	18 (3.6)	....	... ...
1957.....	350	16 (4.6)	16 (4.6)	30 (8.6)	... ...	....	... ...
1958.....	193	11 (5.7)	20 (10.4)	....	....	....	... ...

* Figures in parentheses are percentages recovered.

the angling season, for a minimum exploitation rate of 0.09. The pr portions recovered in these areas, when tested by chi-square, did not dif significantly from that recovered at Constantia in the same year.

Survival. Survival of the Constantia population was estimate from a catch curve and from the ratio of tag recoveries in successive yea

The age composition of each year's trapnet catch of smallmou bass is given in Table 1. Data for the five years were combined and ea year's catch was given equal weight to smooth the age frequency distr bution. Geometric mean survival computed from the catch curve w 0.55 for ages V to X. Combining samples for five years did not co pletely eliminate distortion in the catch curve caused principally variations in year class strength. Fluctuations in minimum rates of e ploitation from tag returns indicate annual survival probably varied whi would cause further irregularities in the catch curve. The estimate survival of 0.55 from the catch curve approximates the average surviv during the period from about 1950 to 1955 when the age groups sampl were recruited into the legal size category. Sanderson (1958) obtained lower survival rate of 0.43 from a catch curve of age II to VII smallmou bass from the Potomac River.

When marking is done at the start of fishing in two consecutive yea the formula:

$$S_1 = \frac{R_1 \cdot M_2}{M_1(R_{22} + 1)}$$

can be used to estimate survival (S_1) during the first year of taggi

icker, 1958). Here, M_1 and M_2 are the numbers of tagged fish released years 1 and 2, respectively, while recaptures, in the second year, of marked in the first and second years are represented by R_{12} and R_{22}, pectively. In applying this formula to tag recoveries for smallmouth ss in Oneida Lake, it is assumed that the mortality rate was the same all age groups in a given year. Although it would be desirable to mpute annual survival rates by age groups, the number of tag recoveries s inadequate.

Tag recoveries reported by anglers in 1955 through 1958 were sub-tuted in the formula. Estimated survival was 0.32 in 1954, 0.51 in 55, 0.41 in 1956 and 0.73 in 1957. The low survival of 0.32 in 1954 es not appear reasonable since the minimum rate of exploitation from returns was lower in 1954 than in 1955 or 1956. Further evidence t this is an underestimate can be obtained by calculating survival m the number of the bass tagged in 1954 that were caught in 1956. rvival for the 2-year period 1954 and 1955 was 54 (499)/108 (828) = 0. The square root of 0.30 or 0.55 is the mean annual survival rate the Constantia bass population in 1954 and 1955.

The low estimate of 1954 survival, from tag recoveries in 1955, ggests that tagged fish released in 1955 were more vulnerable to angling an were the survivors of those released in 1954. In 1954 bass were eased within 1 mile of Constantia, but in 1955 bass were released at eral points 5 to 15 miles from the netting sites near Constantia. Per-ps displaced bass are more vulnerable to angling than bass released their home territory, or fishing pressures in 1955 may have been lower Constantia than in other areas. Although the survival of bass in 1954 nnot be estimated from tag returns, the estimate of 1955 survival is nsidered reliable since the majority of the bass released in 1955 had urned to the Constantia area by 1956 and would have experienced same rate of exploitation in 1956 as bass tagged and released at Con-ntia in 1956.

The foregoing estimates of survival from tag returns are based on coveries in the first and second seasons following release. Since, in Oneida Lake bass fishery, substantial numbers of recoveries are made nd 4 years after release, it is desirable to include these recoveries in survival estimate. It is apparent from inspection of Table 9 that rvival in 1955, for example, can be estimated from the ratios of the ss tagged from 1955 to 1956 that were recovered in the 1957, 1958 d 1959 fishing seasons as well as in the 1956 fishing season, assuming mortality rate was the same for all age groups. Recoveries in suc-sive years were combined in the expression:

$$S_1 = \frac{R_{12} + R_{13} \ . \ . \ . \ + R_{1n}M_2}{R_{22} + R_{23} \ . \ . \ . \ + R_{2n}M_1}$$

where notations are those of Ricker (1958) and were used in the preced formula. Survival rates calculated from tag returns for the years 1 to 1959 (Table 9) were 0.48 in 1955, 0.42 in 1956 and 0.82 in 1 These estimates based on combined recoveries in successive years similar to those calculated from the ratio R_{12}/R_{22}.

Natural mortality of the Pacific sardine was estimated by Wi (1954) from a series of paired values for survival and effort using a gression of instantaneous total mortality rate from age composition c on fishing effort. Beverton and Holt (1957, p. 195) noted that the sa procedure will lead to an estimate of "other loss" (natural mortality, loss and tagging mortality) using recoveries of marked fish from sev liberations. It is assumed in Widrig's method that natural mortalit constant and fishing effort is proportional to the instantaneous rat mortality from fishing. The latter assumption probably does not h in many warm-water sport fisheries (Lux and Smith, 1960). Howe it is reasonable to suppose that annual fluctuations in minimum rate exploitation estimated from angler tag returns should reflect proportio changes in the true rate of exploitation, if anglers return tags in pro tion to the numbers of tagged fish caught. Given a series of minim rates of exploitation and total mortality rates, it should be possibl calculate the constant rate of natural mortality necessary to give observed relation between total mortality and minimum exploitation r

Expressing mortality components as instantaneous rates (Ric 1958), total mortality (i) equals fishing mortality (p) plus natural m tality (q) or:

$$i = p + q.$$

Under certain conditions[3]:

$$p = u \frac{i}{a}$$

but if the observed exploitation rate is a minimum estimate (u'), whi proportional to the true exploitation rate, then:

$$p = C\,(u' \frac{i}{a})$$

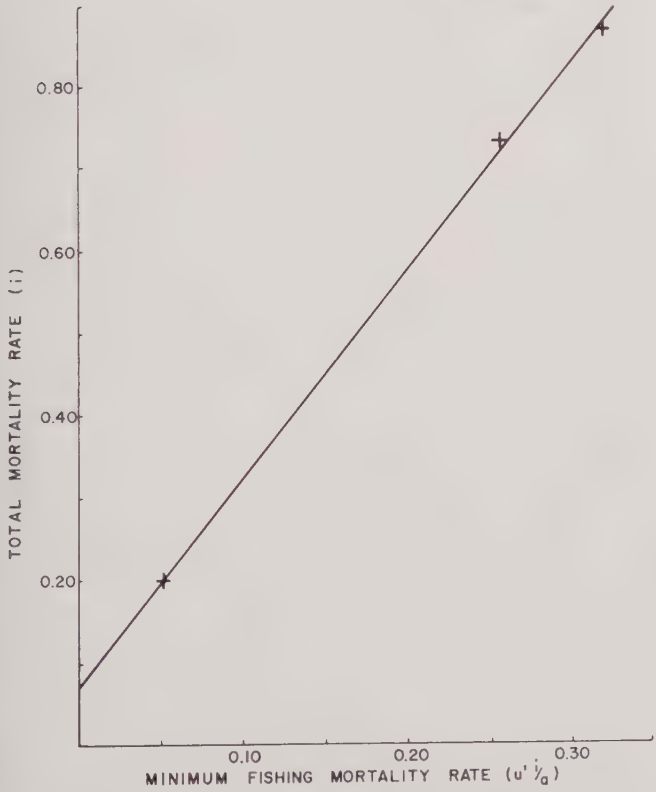
where C is a constant. Since q is assumed to be constant the expres

$$i = C\,(u' \frac{i}{a}) + q$$

[3] Strictly applicable where fishing and natural mortality are distributed pr tionately within the year. However, if the distribution of natural and fis mortality is consistent in successive years the subsequent estimate of na mortality will be unaffected.

a linear equation which can be solved if a series of values for $u' \frac{i}{a}$ d i are available. The value of q will be obtained when $u' \frac{i}{a}$ is extra- lated to zero.

Figure 2 shows the regression line fitted to i and $u' \frac{i}{a}$ from recoveries bass tagged from 1955 to 1958. The intercept of 0.08 on the i axis is estimate of the instantaneous natural mortality rate, q. Slope of the gression line measures the relation between the true exploitation rate and e minimum rate determined from voluntary tag returns. The slope efficient of 2.5 indicates that the true rate of exploitation from 1955 to 57 may have been 2.5 times the minimum rate estimated from tag urns.



ure 2. Instantaneous total mortality rate and minimum instantaneous fishing mortality from smallmouth bass tag returns for the years 1955–1958. Intercept of regression on i axis estimates instantaneous natural mortality rate.

The natural mortality rate calculated for smallmouth bass in Oneid Lake from the intercept of $u' \frac{i}{a}$ on i must be considered at best a crud approximation. Variation in the proportion of tags reported by angler tag loss and mortality at tagging could cause serious errors in the estimat of natural mortality. But the method may provide a useful check o more refined estimates of mortality components.

Few data on mortality rates of smallmouth bass have been reporte Latta (1958) calculated a survival rate of 0.42 for a population of smal mouth bass in Lake Michigan from recoveries for bass tagged in tw successive years. An exploitation rate of 0.22 was obtained from a cre census and population estimate. Expectation of death from natur causes (v) obtained by subtraction was 0.36 and corresponds to an instan taneous mortality rate (q) of 0.54 which is much higher than that calc lated for bass in Oneida Lake. Fraser (1955) concluded from a cre census and tagging program that 60 per cent of the smallmouth ba tagged were caught by anglers in a period of four to five years, the r maining 40 per cent presumably dying from natural causes, but annu mortality rates were not given. Much additional information o mortality components in exploited populations is needed as a basis f sound management of the smallmouth bass.

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LATE FALL, WINTER AND EARLY SPRING FOODS OF 141 OTTERS FROM NEW YORK[1]

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ABSTRACT

The contents of stomach and intestines of 141 otters from the Adirondack regio of New York, taken from late fall to early spring, were analyzed to determine foo habits. Fish occurred in 70 per cent of the specimens, being represented by minnow 35.5 per cent; sunfish and black bass, 12.1 per cent; perch, 9.3 per cent; suckers, 6 per cent; trout, 5 per cent; catfish, 2.1 per cent; sculpins, 2.1 per cent; mudminnow 1.4 per cent; pickerel, 0.7 per cent and undetermined fish, 12.8 per cent. Crayfi were eaten by 34.7 per cent, frogs and their tadpoles by 24.8 per cent, and aquat insects occurred in 13.5 per cent of the otter. Mammals, including two instances muskrats, occurred in 4.3 per cent while one otter had eaten a bird.

The otter (*Lutra c. canadensis*) has a rather extensive distribution the Adirondacks of New York and occurs sporadically in several oth areas of the State. Within the past 20 years, it appears to have extende its range and increased in numbers. An average of 285 otters we trapped and legally tagged per season during the four years from 1955 to 1958–59. Prejudice against the otter is often evident among fisherme who blame this predator for their poor fishing success on their favor trout waters. No published data are available on the food of the ott in New York, although its food habits have been the subject of resear in several other states.

The early spring food of otters in Michigan was reported by Lag and Ostenson (1942), who examined 95 stomachs and 133 intesti Forage fish (mudminnows, sculpins, minnows, sticklebacks, suckers a darters) comprised the majority of the food, with game and pan fish crayfish, amphibians and insects contributing the remainder. Ryd (1955) continued the Michigan studies, substantiating the observations Lagler and Ostenson. He concluded that the otter captures fish in pr portion to their abundance, and indicated that the predatory habits the otter may actually benefit trout by removing the less desirable (a usually slower moving) competitive fishes from trout waters. Wils (1959) reported the fall-winter food of otters in coastal North Caroli to consist mainly of fish, principally carp, catfish, suckers and sunfi At other seasons, the food consisted primarily of fish, blue crab and cr fish. Food taken in small quantities included shrimps, clams, wa beetles, decapods, muskrats, rails and waterfowl. Greer (1955) report on 1,374 otter scats from Montana. He recovered fish remains in 9

[1] For supplying many otter carcasses, thanks are due Paul J. Benoit, Welling Benson, Richard F. Emperor, William A. Flick, Lyle LaLone, Ives Turner, A A. Washburn and Frank T. Webb.

per cent, invertebrates in 41.2 per cent, amphibians in 18.4 per cent, mammals in 6.1 per cent, birds in 5.2 per cent and reptiles in 0.4 per cent. In order of importance, fish remains included sunfish, suckers, sculpins and trout. Dragonfly nymphs, aquatic beetles and freshwater shrimp appeared consistently, but seldom made up an appreciable proportion of the scat. Frogs were eaten throughout the year, while muskrat occurred in 51 scats and beaver in 10 scats.

The present study is based on the examination of 141 otter carcasses that contained food. They were trapped in various parts of the Adirondacks from 1951 to 1960. The carcass was eviscerated in the laboratory and the contents of the stomach and intestinal tract stripped of food, placed in a fine-meshed food strainer and washed under a strong flow of tap water. The food was then placed in a white enamel pan and the identifiable contents removed. Stomach and intestinal parasites were preserved for study. The numbers of specimens for different months were: October, 4; November, 38; December, 22; January, 6; February, 4; March, 40; April, 26. More specific effort to trap otters occurs in the late fall while the high numbers taken in later winter and early spring are a result of beaver trapping.

The results of these analyses (Table 1) are similar to those of others who have investigated the food of the otter. Fish were the dominant food, while crayfish and amphibians made up a substantial share of the diet. Following are brief discussions of the major food groups.

Fish

Type of scale, cheekbones, pharyngeal teeth and other characters were used to identify the fish. The minnows comprised more than half of the species eaten. Often 14 pairs of pharyngeal teeth were recovered from a single stomach. In order of their frequency of occurrence, the following genera were identified: *Rhinichthys*, *Semotilus* and *Notropis*. Several of these had total lengths of less than 60 millimeters and few cyprinids exceeded 150 millimeters. The centrarchids included smallmouth bass and sunfish. Yellow perch were frequently eaten. Charles M. Garney of Crown Point (N. Y.) reported he has frequently seen remains of partly eaten perch at otter feeding sites. The distinctive pharyngeal teeth of suckers were recovered from nine otters; judging from their size, the fish were 200 millimeters or longer. Trout are difficult to recognize once they have passed beyond the stomach, but the vomers, when recovered, are unmistakable. Bullheads (*Ameiurus nebulosus*) were recognized in three specimens. Both sculpins and mudminnows seek the mud and bottom litter of streams and lakes when disturbed, and quite possibly are stirred up when otters search the bottom for food. Greer (1955) found sculpins in 18.5 per cent of 1,374 otter scats. These small fish

Table 1. The Fall, Winter and Early Spring Food of 141 Otters from Ne York

Food	Number of occurrences		Percentage frequency	
Fish	99		70.2	
Cyprinidae (minnows)		52		35.5
Centrarchidae (bass, sunfish)		17		12.1
Percidae (perch)		13		9.3
Catostomidae (suckers)		9		6.4
Salmonidae (trout, etc.)		7		5.0
Ameiuridae (catfish)		3		2.1
Cottidae (sculpins, muddlers)		3		2.1
Umbridae (mudminnows)		2		1.4
Esocidae (pike, pickerel)		1		0.7
Undetermined fish		19		12.8
Crayfish	49		34.7	
Amphibia	35		24.8	
Insects	19		13.5	
Mammals	6		4.3	
Birds	1		0.7	

are associated with brook trout and are reputed to eat trout spaw Eleven mudminnows were recovered from one otter stomach.

Crayfish

The high incidence of crayfish in the diet of the otter has been co mented upon by several investigators. In the present study, the stoma was frequently devoid of food, while the large intestine was solidly pack with the crushed exoskeletal fragments of crayfish.

Amphibia

Frogs, chiefly *Rana clamitans*, occurred in 27 otters, while tadpoles h been eaten by six otters. One stomach contained the remains of large tadpoles, presumably *Rana catesbeiana*. These were from ott taken in large quiet streams and lakes, during the coldest weather, wh the animals obviously had had to grub the bottom for the dorm amphibians. A single newt was taken from one stomach.

Insects

Astonishingly large numbers of aquatic insects were eaten by otters examined. Most were ingested during the midwinter, and not appear to be of secondary origin, i.e., first eaten by fish. La stonefly nymphs (*Perla*) often numbered a dozen or more in a stoma while tipulid larvae, dytiscid beetles, larvae of the sialid *Chauliodes* a caddis worms were eaten. We presume such tidbits are the entrees more substantial meals.

Mammals

Two otters had eaten muskrat, while one each contained the remains of a smoky shrew (*Sorex fumeus*), field mouse (*Microtus pennsylvanicus*), red-backed mouse (*Clethrionomys gapperi*), and mink (*Mustela vison*). Greer (1955) found muskrat remains in 18.7 per cent of 252 otter scats taken at Gary's Lake in Montana. Charles Garney reported that he has seen where otter have captured and eaten muskrats near Crown Point (N. Y.). While many of the otters examined in the present study were taken in inhabited beaver ponds, no predation on beaver was noted. Greer (1955), however, listed beaver remains in 0.7 per cent of 1,374 otter scats.

Birds

Crow feathers were recovered from one otter and may represent carrion. A. E. Emerson of Dexter (N. Y.) stated that "While beaver trapping in 1952 I saw an otter track with blood in some of the footprints. I followed it backwards, probably 300 yards, and from the evidence it had caught a partridge and eaten it."

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TOXICITY OF 2-*SECONDARY*-BUTYL-4,6-DINITROPHENOL TO BLACKNOSE DACE AND RAINBOW TROUT

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ABSTRACT

The toxicity of 2-*secondary*-butyl-4,6-dinitrophenol to fish life, using western blacknose dace and rainbow trout as test fish, was determined by a flow-through technique. The tests with the blacknose dace were carried out at 70° F. and those with the trout at 65° F. The values for the 24-hour median lethal concentration (24-hour LD_{50}) were: for blacknose dace, 0.24 p.p.m. at pH 8.0; for rainbow trout, 0.30 p.p.m. at pH 8.0 and 0.073 p.p.m. at pH 6.9. The concentrations required to produce complete mortality for exposure periods up to about 4 hours were also investigated. The data indicate, for rainbow trout, that when the pH changed from 6.9 to 8.0 the concentration required to bring about any fixed mean time to death had to be increased about five-fold.

Formulations of the compound 2-*secondary*-butyl-4,6-dinitrophenol[1] and of its salts, especially the ethanolamine and isopropanolamine salts, are being currently used as herbicides on farms. In recent years several fish kills resulting from the discharge of this weedkiller have been investigated by the Pollution Unit of the Conservation Department. The toxicology of *secondary* butyl dinitrophenol and of related dinitrophenols to plants, insects, and higher animals has been summarized by Negherbon (1959, pp. 289–291 and pp. 303–308). At the time the experiments described below were started no data on the toxicity of the butyl compound to fish life were known to the authors, but in the meantime Webb (1961) has published data on the toxicity of a commercial preparation to redsided shiners (*Richardsonius balteatus hydroflox*).

PROCEDURE

The material used for the bio-assays was 2-*secondary*-butyl-4,6-dinitrophenol, #T7032 (Technical Grade) as prepared by Matheson, Coleman and Bell; no information is available about the percentage purity or about the nature of the impurities. A stock solution was prepared in distilled water containing just enough sodium hydroxide to dissolve the free dinitrophenol. All concentrations are in terms of the sample.

The test fish were blacknose dace (*Rhinichthys atratulus*) seined from Green Gulf Brook at the bridge on the side road at Springwater in Livingston County and small rainbow trout (*Salmo gairdneri*) obtained from the Caledonia State Fish Hatchery through the courtesy of Earl Styles, the foreman. The blacknose dace were held in troughs in the laboratory

[1] The formula for this compound is $(O_2N)_2$ (C_4H_9) C_6H_2OH. Some commercial designations of its salts are Sinox, Dinoseb, DNBP, DNOSBP, and DNSBP.

or a little over 2 months before use. All the fish were brought up to the test temperature from initial temperatures of 46–49° F. over a 3- to 5-day period. All fish were held at the test temperature from 3 to 12 days before use in any assay, except that one set of 10 fish was held for only 1 day before use. The fish were all fed finely ground liver with the blacknose dace receiving some bread crumbs in addition. None of the fish received any food for 48 hours before use. Mortality was very slight in the stocks of fish used and never exceeded 10 per cent. The weights and sizes of the fish are given in footnotes to Tables 1, 2, 3, and 5.

The bio-assays were conducted in cylindrical 5-gallon Pyrex jars filled to capacity, using a flow-through technique. Test solutions of the appropriate concentrations and pH values were prepared in 12-gallon Pyrex carboys and transferred to the assay jars at rates varying between 4 and 6 liters per hour; flow rates were measured with flow-meters. The assays with the blacknose dace were run at 70° F.; those with the trout, at 55° F. All the tests were carried out in constant-temperature tanks; the reservoir carboys and the test jars were immersed in water the temperature of which did not depart more than ± ½° F. from the designated test temperature. Taylor recording thermometers were used to record the water temperatures in the tanks.

The dilution water was the laboratory tapwater, which is furnished from the Hemlock Lake water supply of the City of Rochester. The following analysis is taken from the data cited by Grossman and Yarger (1953). Except for pH and specific conductance, all figures are in parts per million.

Silica (SiO_2)	3.5
Calcium (Ca)	22
Magnesium (Mg)	5.8
Sodium (Na)	3.0
Potassium (K)	2.4
Bicarbonate (HCO_3)	59
Sulfate (SO_4)	26
Chloride (Cl)	5
Dissolved solids	101
Hardness (as $CaCO_3$)	
Total	79
Carbonate	49
Specific conductance (in micromhos at 25° C.)	170
pH	7.4

The water used for the bio-assays was not analyzed, but analyses made from time to time in this laboratory have given results comparable with the above data, except that the pH has been about 8.0. It is believed that the higher pH is a consequence of using a transite pipe as the water main supplying the laboratory.

All of the assays with the blacknose dace, and some of those with the trout, were carried out with initial pH values of about 8; in a few instances the pH had to be adjusted by adding a small amount of hydro-

chloric acid (1:4). The remaining assays with the trout were run wit initial pH values of about 6.9, the pH being adjusted in the same wa

Ten fish were used for each concentration and pH level. Death wa taken as the end-point, and the criterion for death was cessation of a gill movement. Dead fish were removed from the assay jars from time t time; since the tests were not under continuous observation, and th actual times of death were therefore not always observed, some of the dea fish remained in the test jars before being removed.

For the assays with blacknose dace, nitrogen gas was bubbled throug the dilution water, before adding the dinitrophenol, until the dissolve oxygen concentration was reduced to the range of 7–8 p.p.m. No pre liminary bubbling with nitrogen was done with the dilution water use for the assays with trout. Dissolved oxygen concentrations and pH valu were determined in the test jars from time to time; the dissolved oxyge determinations were made by the sodium azide modification of th Winkler method (American Public Health Association, 1955, p. 255), an pH was measured with a Leeds and Northrup Model 7663–A1 pH mete using a glass electrode-saturated calomel electrode pair.

RESULTS

Tables 1, 2, and 3 give the mortalities during a 24-hour exposur period, over a range of concentrations. In addition, the tables contai the results of the pH and dissolved oxygen determinations as well as com ments on the conditions of the surviving fish.

The 24-hour median lethal concentration (LD_{50}), i.e., the concen tration required to kill exactly half the fish in 24 hours, was calculate for each set of conditions (species and pH) using a probit analysis (Finney 1952, pp. 48–55). The fiducial limits at the 5 per cent probability leve were also calculated (Finney, 1952, pp. 36–37); these limits are such tha if the calculated LD_{50} values are true, estimates of LD_{50} exceeding th limits would occur in only 5 per cent of the trials. (The entire calculatio was carried out in terms of logarithms, and the calculated values wer then converted back to concentration terms). The results are given i Table 4. The probit regression equations

$$Y = 1.70 + 8.60X \text{ for blacknose dace}$$
$$Y = 1.89 + 6.58X \text{ for rainbow trout at the higher pH}$$
$$Y = -0.586 + 6.49X' \text{ for rainbow trout at the lower pH}$$

where

Y = probit of the expected proportion killed
X = logarithm of 10 times the concentration
X' = logarithm of 100 times the concentration

are represented graphically in Figure 1. The probits on a linear scale ar plotted against concentration on a logarithmic scale; the percentages o

TABLE 1. TOXICITY OF DIFFERENT CONCENTRATIONS OF *Secondary* BUTYL DINITROPHENOL TO BLACKNOSE DACE DURING 24-HOUR EXPOSURES AT 70° F. AND pH 8 *

Concentration (p.p.m.)	Mortality in 24 hours (per cent)	Initial pH of test solution	Observed range of pH values in assay jar	Initial dissolved oxygen concentration of test solution (p.p.m.)	Range of observed dissolved oxygen concentrations in assay jar (p.p.m.)	Condition of surviving fish at end of test period
0.15	0	8.22	8.01	7.5	6.9–7.3	No observable distress
0.18	10	8.01	....	7.3	6.4–7.2	Five at surface
0.20	30	8.0	7.95	7.3	6.8–7.1	One in distress
0.25	50	8.1	....	7.3	7.1–7.2	No observable distress
0.27	70	8.10	7.80–8.04	7.3	6.7–7.1	No observable distress
0.30	90	8.1	8.05	7.4	6.8–7.1	Surviving fish had lost equilibrium during test, but was apparently recovering at termination
0.40	90	8.04	....	7.3	7.0–7.2	In obvious distress
0.50	100	8.20	8.03–8.18	7.4	6.8–7.2	.....

* Ten fish used at each concentration. For 77: total length averaged 3.7 centimeters (range 2.3–4.8); weight averaged 0.387 gram (range 0.15–0.9).

mortality corresponding to the probits are shown on a probability scale on the right-hand vertical axis. The individual points are the experimental results.

A second series of assays was run with concentrations high enough to cause relatively rapid mortality. Ten fish were used for each assay, and the time to death of each fish was observed. The times to death, in minutes, were converted to common logarithms, and the mean logarithm and the standard deviation of the logarithm were calculated for each assay. The standard deviation of each mean logarithm was calculated from the formula

$$\text{standard deviation of mean logarithm} = \frac{\text{standard deviation of logarithm}}{\sqrt{10}}$$

and the 95 per cent confidence limits of each mean logarithm were calculated from the formula

$$\text{limits} = \text{mean logarithm} \pm a \times \text{standard deviation of logarithm}$$

Table 2. Toxicity of Different Concentrations of *Secondary* Butyl Dinitrophenol to Rainbow Trout During 24-Hour Exposures at 65° and pH 8*

Concentration (p.p.m.)	Mortality in 24 hours (per cent)	Initial pH of test solution	Observed range of pH values in assay jar	Initial dissolved oxygen concentration of test solution (p.p.m.)	Range of observed dissolved oxygen concentrations in assay jar (p.p.m.)	Condition of surviving fish at end of test period
0.15	0	8.02	7.86–8.04	.....	9.16–11.04	No observable distre
0.175	10	8.01	7.79–7.96	.....	10.24	No observable distre
0.225	20	7.98	7.89–7.96	.....	10.2	No observable distre
0.25	40	7.99	7.81–7.98	.....	10.1	No observable distre
0.275	50	8.06	7.75–7.94	.....	.....	No observable distre
0.30	40	8.06	7.82–7.92	.....	.....	All in distress, on barely keepin equilibrium
0.35	50	8.09	7.87–7.91	.....	10.0	One in distress
0.375	60	7.93	7.69–7.94	.....	.....	All in obvious distre
0.40	90	7.87	7.74–7.92	.....	.....	No observable distre
0.45	100	8.2	7.84–8.00	.....	.....	.....

* Ten fish used at each concentration. For 44: total length averaged 4.15 cent meters (range 3.3–5.2); no data on weights or for survivors.

where $a = 0.754$ for sample size 10 (American Society for Testing Mater ials, 1951, p. 43).

Table 5 gives these parameters, together with the anti-logarithms o the mean logarithms and of the 95 per cent confidence limits of the mea logarithms. The data for the blacknose dace are incomplete, since pH values were not determined: it is considered likely, from initial pH values determined on assays made a few days earlier, that the pH wa about 8.

The data for the rapid mortality of the rainbow trout are represente graphically in Figure 2, where the anti-logarithm of the mean logarithm of the time to death is plotted against the concentration, both on logarith mic scales, and the straight lines have been fitted by eye. The points fo the anti-logarithms of the 95 per cent confidence limits are also marked

Finally, a pair of bio-assays were conducted at a fixed concentratio of 0.5 p.p.m., but at two different pH values. The rate of flow was hig

ABLE 3. TOXICITY OF DIFFERENT CONCENTRATIONS OF *Secondary* BUTYL DINITROPHENOL TO RAINBOW TROUT DURING 24-HOUR EXPOSURES AT 65° F. AND pH 6.9*

oncentration p.p.m.)	Mortality in 24 hours (per cent)	Initial pH of test solution	Observed range of pH values in assay jar	Initial dissolved oxygen concentration of test solution (p.p.m.)	Range of observed dissolved oxygen concentrations in assay jar (p.p.m.)	Condition of surviving fish at end of test period
0.025	0	6.91	6.85–6.90	.....	.....	No observable distress
0.050	20	6.90	6.91	.....	10.0	In distress
0.075	40	6.91	6.88–6.92	.....	9.56	In distress
0.100	90	6.90	6.86–6.92	.....	10.1–10.4	In distress
0.125	90	6.91	6.90–6.94	.....	.....	No observable distress
0.150	100	6.91	6.83–6.91	.....	.....	.....

*Ten fish used at each concentration. For 34: total length averaged 4.36 centimeters (range 3.3–5.3). For nine, weight averaged 0.56 gram.

ABLE 4. 24-HOUR MEDIAN LETHAL CONCENTRATIONS OF *Secondary* BUTYL DINITROPHENOL FOR BLACKNOSE DACE AND RAINBOW TROUT

Species	Temperature (in degrees F.)	Nominal pH	LD_{50} (p.p.m.)	Limits* (p.p.m.)
acknose dace...	70	8.0	0.24	0.22 and 0.26
ainbow trout...	65	8.0	0.30	0.27 and 0.33
ainbow trout...	65	6.9	0.073	0.061 and 0.086

*Represent fiducial limits at the 5 per cent probability level.

nough to maintain a constant pH for the duration of each assay, the pH eing measured at approximately 15-minute intervals. The data are iven in Table 6.

DISCUSSION

The data in Tables 1, 2, 3, and 4 show that 2-*secondary*-butyl-4,6-initrophenol is toxic to fish at low concentrations.

The values for the 24-hour median lethal concentration reported here re in fair agreement with those reported by Webb (1961). Working ith a commercial preparation reported to contain *secondary* butyl dini-rophenol and *secondary* amyl butyl dinitrophenol in a 5:1 ratio, he found,

Table 5. Acute Toxicity of *Secondary* Butyl Dinitrophenol for Rainbow Trout and Blacknose Dace *

Concentration	Observed pH range	Time to death in minutes					
		Mean logarithm	Standard deviation of logarithm	Standard deviation of mean logarithm	95 per cent confidence limits of mean logarithm	Anti-logarithm of mean logarithm	Anti-logarithms of 95 per cent confidence limits of mean logarithm
Rainbow trout at 65° F.							
1	7.75–8.01	1.9996	±0.1517	±0.04797	2.1140–1.8852	99.9	130 – 76.8
2	7.88–8.05	1.6241	±0.1784	±0.05641	1.7586–1.4896	42.1	57.4– 30.9
5	8.1	1.1291	±0.06519	±0.02061	1.1783–1.0799	13.5	15.1– 12.0
0.15	6.93	2.1216	±0.1524	±0.04819	2.2365–2.0067	132	172 –102
0.20	6.91–7.28	2.0299	±0.2206	±0.06976	2.1962–1.8636	107	157 – 73
0.30	6.95–7.15	1.7530	±0.1666	±0.05268	1.8786–1.6274	56.7	75.6– 42.4
Blacknose dace at 70° F.							
1	.....	2.2621	±0.09731	±0.03077	2.3355–2.1887	183	216 –154
5	.....	1.7853	±0.1020	±0.03226	1.8622–1.7084	61	72.8– 51.1

* Ten fish used at each concentration.
For 30 rainbow trout at high pH: total length averaged 4.8 centimeters (range 3.7–5.6); weight averaged 0.94 gram.
For 30 rainbow trout at low pH: total length averaged 3.8 centimeters (range 3.4–4.3); weight averaged 0.74 gram.

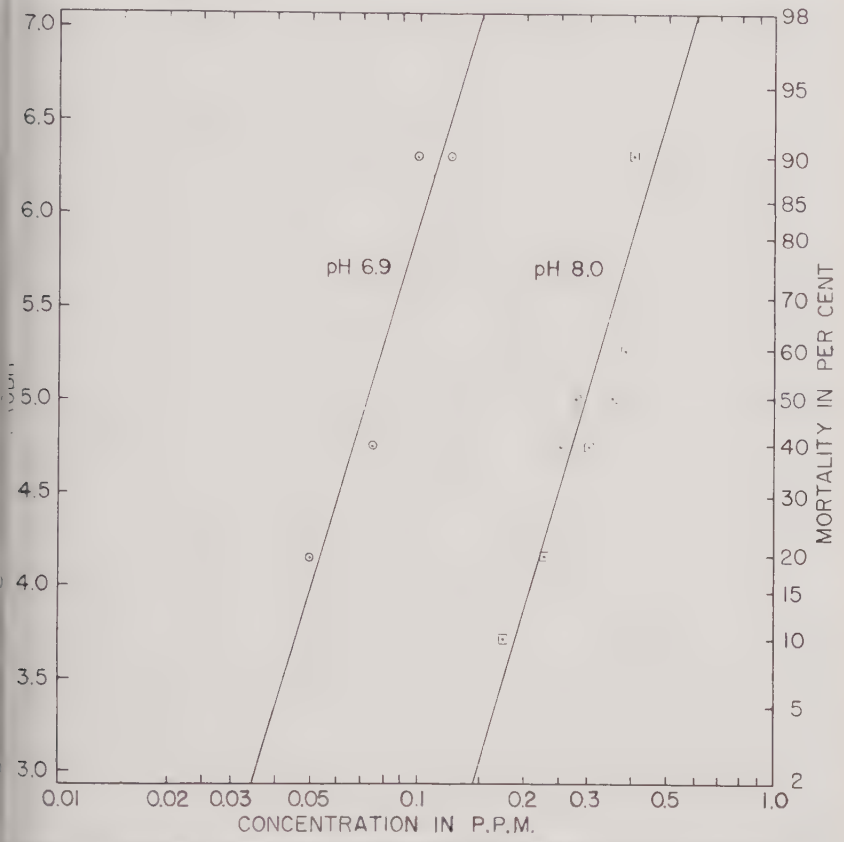

Figure 1. Relation between the concentration of *secondary* butyl dinitrophenol and the degree of mortality among rainbow trout during a 24-hour exposure period for two pH levels.

Table 6. Influence of pH on the Toxicity of a 0.5 p.p.m. Concentration of *Secondary* Butyl Dinitrophenol to Rainbow Trout at 65° F.*

Level of pH	Time to death in minutes					
	Mean logarithm	Standard deviation of logarithm	Standard deviation of mean logarithm	95 per cent confidence limits of mean logarithm	Antilogarithm of mean logarithm	Antilogarithms of 95 per cent confidence limits of mean logarithm
6.91	1.3579	±0.09474	±0.02996	1.2865–1.4293	22.8	19.3–26.9
7.35	1.8347	±0.2154	±0.06811	1.6723–1.9971	68.3	47.0–99.3

*Ten fish used at each level of pH; total length averaged 4.43 centimeters (range 4.0–5.7); weight averaged 1.04 grams.

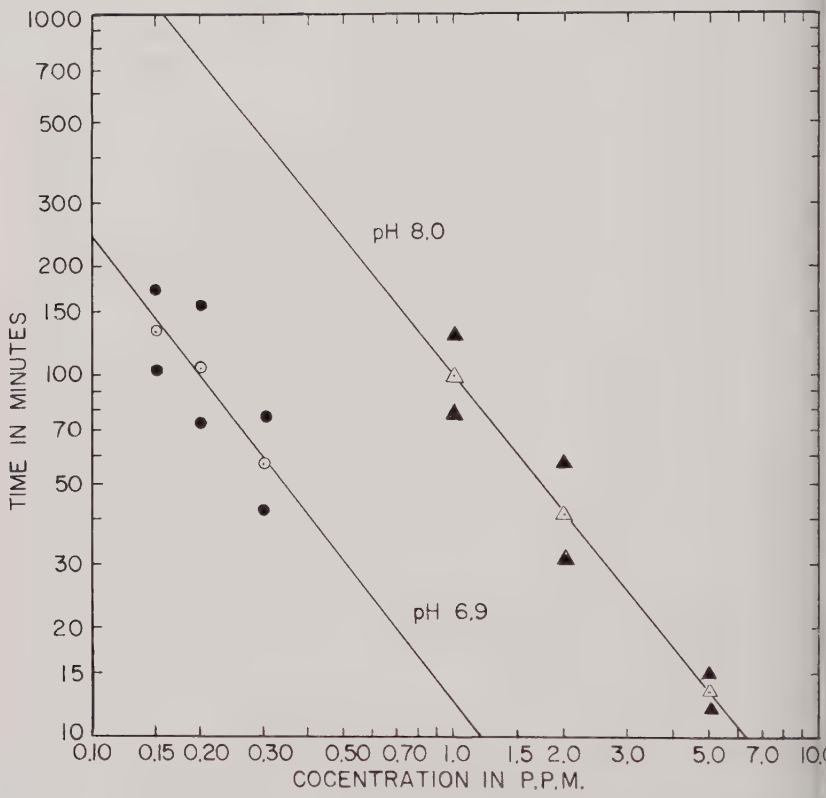

Figure 2. Effect of pH on the rapid mortality of rainbow trout in solutions of *secondary* butyl dinitrophenol. Open symbols represent the experimental values of mean time to death; solid symbols, the 95 per cent confidence limits of the experimentally-determined mean times to death.

using the redsided shiner as his test fish, that the 24-hour median lethal concentrations for a soft water and a hard water were 0.16 p.p.m. and 0.24 p.p.m., respectively; the concentrations are in terms of the 5:1 mixture of the two dinitrophenols. Webb gave the characteristics of the two waters as follows:

soft water — pH 7.6, alkalinity 35 p.p.m., hardness 18 p.p.m.
hard water— pH 8.2, alkalinity 116 p.p.m., hardness 156 p.p.m.

He ascribed the difference in toxicity to the difference in hardness between the two waters, although the results of the present investigation indicate that the difference in toxicity could be accounted for by the difference in pH.

[2] The alkalinity and hardness concentrations are presumably in terms of $CaCO_3$ although not explicitly so given.

The date of Lipschuetz and Cooper (1955) permit a comparison of ne toxicity of the butyl dinitrophenol with the toxicity of potassium cya- ide. The 24-hour LD_{50} of the dinitrophenol to the blacknose dace was .24 p.p.m., and that of the cyanide was 0.22 p.p.m. (as CN), at a tem- erature of about 69° F. and with a pH of 7.9 -8.0. Expressed in this way he two compounds have approximately the same toxicity. When the oncentrations are expressed in terms of molarities, it is seen that the dini- rophenol is more toxic to the blacknose dace over a 24-hour exposure eriod, the 24-hour LD_{50} being 1×10^{-6} molar and 8.5×10^{-6} molar for he nitrophenol and the cyanide, respectively.

The relation between the dinitrophenol and potassium cyanide is ltered when the concentrations are high enough to cause death during a elatively short exposure period. The anti-logarithm of the mean log- rithm of the time to death, for blacknose dace in a potassium cyanide oncentration equivalent to 0.40 p.p.m. CN, was 76.3 minutes as calcu- ated from the data in Table 4 of Lipschuetz and Cooper (1955); the anti- garithms of the 95 per cent confidence limits of the mean logarithm of he time to death were 50.8 minutes and 115 minutes. For the dini- rophenol (Table 5), the anti-logarithms of the mean logarithms of the me to death were 183 minutes (with 95 per cent confidence limits corre- ponding to 154 and 216 minutes) for 1 p.p.m. and 61 minutes (with 5 per cent confidence limits corresponding to 51.1 and 72.8 minutes) r 5 p.p.m. Plotting the mean logarithm of the time to death against the garithm of the concentration, and making a linear interpolation, it is alculated that about 3.5 p.p.m. of the dinitrophenol would be required produce a mean time to death of 76 minutes. Thus to produce rapid ortality the concentration of the dinitrophenol must be about eight mes that of the cyanide in terms of weight per unit volume. However, hen the concentrations are expressed in terms of molarities, the two bstances are approximately equivalent; potassium cyanide equivalent a 0.40 p.p.m. CN is 1.5×10^{-5} molar, and 3.5 p.p.m. of the dini- rophenol is also about 1.5×10^{-5} molar.

The data summarized in Tables 4, 5, and 6 suggest that the toxicity f the dinitrophenol is greatly influenced by the pH of the solution, at ast in the range of about 7 to 8. Thus a change in pH from about 8 to bout 6.9 reduced the 24-hour LD_{50} from 0.30 to 0.073 p.p.m. for the rain- ow trout at 65° F. (Table 4); a decrease in pH of 1 unit reduced the 4-hour median lethal concentration by about 75 per cent. In a con- ntration of 1 p.p.m. the mean time to death for rainbow trout at 65° F. as about 100 minutes when the pH varied in the range 7.75–8.01, but hen the pH varied in the range 6.91–7.28 the concentration required give a mean time to death of 100 minutes was slightly greater than 20 p.p.m. (Table 5). Finally, for rainbow trout exposed to 0.50 p.p.m.,

the mean time to death was close to 23 minutes when the pH was 6.9 but it was 68 minutes when the pH was 7.35 (Table 6).

Since the pH was adjusted by adding hydrochloric acid, carbo dioxide was formed to some extent, and the question of the possible effec of the carbon dioxide on the results becomes pertinent. Assuming that a the hydrochloric acid reacted with the bicarbonate in the water to for free carbon dioxide, and knowing the amounts of the acid that were use it is calculated that the greatest possible concentration of carbon dioxid was 12 p.p.m. The literature gives rather sketchy information concernin the toxicity of carbon dioxide, but from the summary by Doudoroff (i Brown, 1957, pp. 411–412), it is concluded that a concentration of 1 p.p.m. would not be lethal. This conclusion is reinforced by the fact tha when the dinitropheol concentration was 0.025 p.p.m., the rainbow trou were able to survive for 24 hours without showing signs of distress. Blac *et al.* (1954), in measuring the influence of carbon dioxide on the utilizatio of dissolved oxygen by 16 different species of freshwater fish (neither black nose dace nor rainbow trout were included), found that 12 p.p.m. carbon dioxide had no effect on the utilization of dissolved oxygen. Ther is no information at hand which permits an answer to the question whether the action of the dinitrophenol is influenced by the presence the carbon dioxide, apart from the effects of the changes in pH.

Secondary butyl dinitrophenol is a weak acid, with a pK′ value[3] about 4.5. Simon and Beevers (1951) summarized the effects of th nitrophenols and the halogen-substituted phenols on such physiologic processes as rate of cell division of fertilized eggs, rate of respiration various animal and plant species, and rate of growth of various anim and plant species. They showed that, if the logarithm of the standar response (where the standard response, for example, might be the co centration required to produce a 50 per cent reduction in the respirati rate during some fixed time period) is plotted on the vertical axis again pH on the horizontal axis (using linear scales on both axes), the curve essentially horizontal, as the pH increases, to a point about 1 pH un below the pK value; then it rises linearly with further increase in pH The work reported here was done in the pH range of about 6.9 to 8.0, range which is above the pK value and in which, according to Sim and Beevers, there should be a dependence of toxicity on pH. Th 24-hour median lethal concentrations for rainbow trout at 65° F. we 0.073 p.p.m. at pH 6.9 and 0.30 p.p.m. at pH 8.0 (Table 4). The lo arithms of these two concentrations are respectively −1.137 and −0.52 that is, an increment of 1.1 pH units gave an increment of 0.614 in th logarithm of the 24-hour median lethal concentration, which is equivale

[3] The pK value was not found in the literature; an estimate of its value was obtain by calculation from optical density measurements over a range of pH valu Activities were neglected, and therefore the constant is denoted by pK′, inste of by pK.

o an increment of 0.56 in the logarithm of the 24-hour median lethal concentration per increment of 1 pH unit. The slope of the line in the plot given by Simon and Beevers is equivalent to an increment of about 0.5 n the logarithm of the concentration per increment of 1 pH unit. The xperimental data reported here fit into the general expression given by Simon and Beavers. In the case of the rapid mortality of rainbow rout (Table 5), the increase in the logarithm of the mean time to death or an increase of 1 unit in the pH is about 0.63, a value somewhat higher han the generalized value reported by Simon and Beevers, but yet close nough to be significant.

CONCLUSIONS

It has been shown that *secondary* butyl dinitrophenol can be toxic o some species of fish life at low concentrations and that, within the pH ange in which most surface waters fall, the toxicity becomes greater the ower the pH. The data show that the toxicity of the butyl dinitrophenol s comparable to that of potassium cyanide. The variation in toxicity of ne butyl dinitrophenol with changes in pH has been shown to be in keeping with the biological activities of weak acids as reported by other nvestigators.

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EVALUATION OF CERTAIN TECHNIQUES FOR JUDGING THE AGE OF RED FOXES (*VULPES FULVA*)[1]

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ABSTRACT

It was found that the degree of ossification of the proximal epiphysis of the humer affords a reliable criterion for separating young-of-the-year from adult red fox Study of this feature in seven known-age fox kits showed that closure takes place 9 to 9½ months of age. Age determination by visual examination of the epiphy is reliable for specimens taken from May through February and seems to be the m accurate method studied. X-ray examination is also reliable for the period from M through November at least. The "groove test" (Hale, 1949), as applied to foxes, the most practical method for field use from May through November, especially non-technical personnel.

Ability to judge the age of specimens of a wildlife species is oft of great importance in guiding management programs and determini their effectiveness. In the search for reliable age criteria many studi relating to several anatomical structures, have been conducted. Th have included external characteristics, growth of the skeletal system, too replacement and wear, and the presence or absence of corpora lutea placental scars.

Among the criteria considered have been bone growth and closure the epiphysis. As the body develops, skeletal growth proceeds with t ossification of cartilage, particularly at the epiphyses of the long bon Silverberg and Silverberg (1941) investigated changes in bone and joi in relation to the growth process in laboratory mice, and the same autho (1945) evaluated the effects of sex and breeding on skeletal aging of th animals.

The use of the X-ray for age determination among wildlife w pioneered by Thomsen and Mortensen (1946) who studied the ossificati of the epiphyseal cartilage of the shoulder and elbow regions of cottont rabbits. This technique was further developed and expanded by ot investigators with respect to additional wildlife species. Hale (194 found that the humerus ossified in the cottontail at 9 months of age, wh Petrides (1949, 1951) followed the fusion of the radial and ulnar epiphy in the opossum and the cottontail. Working with dogs, Schlotthau and Janes (1952) followed the closure of the distal femoral and proxi tibial epiphyses and concluded that they close at about 10 months of a

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-35 The authors wish to express their appreciation to and acknowledge the assista of personnel of the special rabies control program in obtaining specimens.

a later study with red foxes and gray foxes, Sullivan and Haugen (1956) ncluded that ossification of the distal epiphyseal region of the radius and lna is complete at 8 to 9 months after birth. Only one study, that of awson (1934) who used laboratory rats, showed failure of the epiphysis close and this was attributed to heredity rather than environmental ctors.

The study reported here was undertaken to review the methods previously described, to determine if certain other epiphyseal regions could used for age criteria, and to derive from some of the methods described r other species a practical, usable field technique for judging the age of d foxes (*Vulpes fulva*). Four methods were compared to determine eir reliability and adaptability. They were: (1) examination by X-ray,) visual examination, (3) the "groove test" as described by Hale (1949), d (4) measurement of the tibia.

MATERIALS AND METHODS

Two approaches were used. First, seven young red fox kits, obtained approximately 6 to 7 weeks of age, were held in captivity and X-rayed periodic intervals to determine the closure of the proximal humeral iphysis. Roentgenograms were made, using selector 1, at 10 milliperes for 1 second at a distance of 32 inches. Second, forelegs and ndlegs from 377 red foxes were collected through the co-operation of bies control trappers from 1953 through 1957. These were tagged at e time of collection giving sex, county, township, date of collection and, some cases, the trapper's estimate of age. From these collections, 337 meri and 318 tibiae were fleshed and then prepared for study by the llowing three-step method: (1) the specimen was placed in a 5 per cent

oximal end of humerus: (left) of juvenile red fox showing open epiphysis; (right) of lt showing epiphysis closed.

solution of ammonia for 24 to 48 hours to loosen and soften the remainin flesh; (2) it was simmered in a 5 per cent solution of sal soda crystals f 30 minutes to an hour depending on the length of time the bone was the ammonia bath; (3) it was brushed clean using a stiff bristle brus The bones then were examined to determine if the proximal epiphysis w open, closing or closed[2].

Roentgenograms were made of humeri collected over a 10-mon period (May through February) to compare the epiphyseal chang during this time. Additional exposures were made on humeri collecte during October, November, December and January to determine t correlation between X-ray and visual examination. All plates were ma from cleaned specimens.

The "groove test" was also applied to these specimens. This t is based on the fact that before ossification is complete the proxim epiphyseal plate of the humerus can be detected by the presence of groove or line which will catch the blade of a knife scraped across it.

Finally, the lengths of 300 tibiae were measured from the med malleous to the median condyle using a vernier caliper. Measureme were read to the nearest 0.01 centimeter, and the condition of the proxim tibial epiphysis was noted.

FINDINGS

Periodic X-rays of the known-age foxes demonstrated that the pro mal epiphysis of the humerus closed at 9 to 9½ months of age. For k born in the last week of March, the epiphysis was found to have closed the second week in January. This information is valuable for use duri the period when young foxes are nearing their full growth (late in No ember and in December) and have the general appearance of adults. factor which should be considered is the variation in the time when k are born. For early litters the epiphysis will close some time in l December, whereas for late litters it will not close until late in Janua or even February. The progress of ossification and fusion of the proxi humeral epiphysis for these foxes is shown in Table 1.

In view of these findings the roentgenograms of the collected sp mens were used to separate young of the year from adults for the mon of May through November. Also, comparison demonstrated compl agreement with the status of these specimens as determined by vis examination. However, due to the limited number of humeri for months of December and January, no conclusion could be reached garding the reliability of this technique beyond the month of Novem

[2] While the conditions of "open" and "closed" are self evident, that of "closing less clear. The latter can be described as that in which the cartilage area is bec ing indistinct and does not catch a knife blade, but careful visual examination fleshed and processed bone or an exposed X-ray plate will reveal its status.

ABLE 1. PROGRESS OF OSSIFICATION OF THE PROXIMAL HUMERAL EPIPHYSIS OF THE RED FOX AS INDICATED BY X-RAY EXAMINATION OF KNOWN-AGE SPECIMENS

Sex	Week of birth*	Date of X-ray						
		1953–54						
		June 17	July 15	Aug. 12	Sept. 10	Nov. 5	Dec. 15	Jan. 8
ale	March 29	§	§	§	§	§	§	closed
ale	March 29	§	§	§	§	§	§	closed
ale	March 29	§	§	§	§	§	§	closed
		1954–55						
		June 10	July 22	Aug. 12	Sept. 9	Nov. 1	Dec. 13	Jan. 11
fale	March 21	§	§	§	§	§	closing	closed
emale	March 21	§	§	§	§	§	§	closed
emale	March 21	§	§	§	§	§	§	closed
emale	March 28	§	§	§	§	§	§	closed

* Estimated when kits were received on May 21 in 1953, and on May 1–4 in 1954.
§ Epiphysis open.

Seton (1925) and Hamilton (1943) stated that foxes from the northastern states are born in late March or early April and that the kits do ot leave the den for 4 to 5 weeks after birth. Visual examination of umeri from 323 foxes revealed that in 107 the proximal epiphysis was pen, in 39 it was closing and in 177 it had closed. The data are given ccording to month of collection in Table 2. In 15 of 33 specimens taken n February the epiphysis had not completely closed. This indicates hat these may have been from late litters of the previous year. Specimens collected in March and April all had the epiphysis closed, with but single exception. However, there is little likelihood of taking young of he year in these months by trapping. Based on this method of judgment, herefore, ossification of the proximal epiphysis of the humerus is complete t approximately 10 months.

The "groove test" is perhaps the most practical technique for field se; therefore, it was applied to all humeri examined in the study. The esults, when compared with those obtained by visual examination, were ound to be reliable for foxes taken during the months of May through Jovember (Table 3).

For animals taken after that, however, its reliability as a criterion or separating adults from all young less than a year old was much less.

Table 2. Comparative Status of the Proximal Humeral Epiphysis for Red Foxes, According to Month of Collection, as Indicated Visual Examination

Month	Status of epiphysis		
	Open	Closing	Closed
April	1	0	13
May	6	0	18
June	17	0	18
July	45	0	31
August	10	0	9
September	15	0	23
October	12	7	10
November	1	14	15
December	0	2	2
January	0	1	4
February	0	15	18
March	0	0	16
Total	107	39	177

Table 3. Accuracy of "Groove Test" in Relation to Results Obtained Visual Examination

Period	Number of humeri	Accuracy (per cent)
May—September	168	100.0
October	23	96.3
November	30	90.0
December—February	38	16.0

This may be attributed to the fact that, although endochondrial ossific tion had just been completed and the epiphysis had recently united wi the diaphysis, the pattern of bony trabeculae could still be recognized as faint indistinct line by careful visual examination. This faint line wou not catch a knife blade in the "groove test".

It seems evident that visual examination is superior to the "groo test". However, as in any biological study, the limitations must be d fined and clearly understood. The visual method requires considerab practice and experience in examining the epiphysis before the investigat can accurately recognize the condition of "closing". The "groove test on the other hand, can be more readily taught to the untrained trapp and should result in greater comparability between the records of differe individuals.

COLLECTION *

Month	Status of epiphysis								
	Open			Closing			Closed		
	Number	Range	Average	Number	Range	Average	Number	Range	Average
April	..	.....	....	..	.....	....	14	13.1–15.8	14.3
May	5	8.6–10.7	9.9	..	.....	....	17	12.3–15.8	14.1
June	18	9.1–12.6	11.0	..	.....	....	18	12.6–15.7	14.2
July	24	11.9–14.5	12.3	..	.....	....	31	12.9–15.3	14.1
August	9	10.6 14.8	13.4	..	.....	....	9	13.6–15.9	14.7
September	13	12.1–15.1	13.7	..	.....	....	21	12.7–15.5	13.9
October	2	14.2 14.7	14.5	4	13.4 14.9	14.4	3	13.5 14.5	13.8
November	1	13.5–13.5	13.5	14	14.0–16.2	14.9	15	12.9–15.1	14.1
December	1	15.1–15.1	15.1	10	13.0–15.5	14.7	16	13.9–16.1	14.9
January	..	.....	....	11	13.7–15.4	14.7	10	12.4–15.2	14.0
February	..	.....	....	5	12.9–15.2	14.0	24	12.7–15.4	13.9
March	..	.....	...	..	.....	...	5	12.4 15.4	13.7
Total	73	XX	XX	44	XX	XX	183	XX	XX

* Length in centimeters; status of epiphysis as indicated by visual examination.

In order to test the reliability of age estimates made by trapper 90 specimens, collected during rabies control trapping in May throug November, were examined. The estimated ages indicated 41.0 per ce were adults, while, by the "groove test", the proportion was 49.9 per cen The size of this sample was small because in many cases estimated ag were not furnished by trappers.

To determine if the length of the long bones could be considered criterion for judging age, the length measurements for the 300 tibia collected were correlated with the status of proximal epiphysis as dete mined by visual examination (Table 4). In these data the tibial length when grouped according to the status of the epiphysis, overlapped i every month except May and June. In the latter months subadults an adults could be separated more easily by the presence or absence epiphyseal grooves. Therefore, tibial length was discarded as a criteri of age.

It was concluded that the degree of ossification of the proxim humeral epiphysis is a reliable criterion for separating young-of-the-yea from adult red foxes. A comparison of the condition of the proxim epiphyses of the humerus and tibia from the same animal in a sample 238 foxes showed that the status in all categories was similar. This agree with the findings of Thomsen and Mortensen (1946) for cottontail rabbi They found that the proximal tibial epiphysis persists at least as long a the proximal epiphysis of the humerus.

The advantages of using the humeral epiphysis for field applicatio are: (1) it is easily described to a trapper who knows little or no anatom and (2) it is adapted to the "groove test". By using this method in th field the trapper is not required to collect or send in any specimens. H can make the "groove test" on the humerus to determine if the catch adult or young, within the limitations of the test, and then discard th carcass.

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EXPERIMENTAL ESTABLISHMENT OF FOOD AND COVER PLANTS IN MARSHES CREATED FOR WILDLIFE IN NEW YORK STATE[1]

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ABSTRACT

Of 125 introductions of 10 species of aquatic plants into 32 wildlife marshes southcentral New York during the period 1955 to 1960, 18 were rated "good", 9 "fair 18 "poor", and 80 were completely unsuccessful when examined in the summer 1960. Of the four species given major emphasis in the planting program (wild ric hard-stem bulrush, three-square bulrush and flowering rush), wild rice was the m successful and offers the greatest promise. Muskrat depredations and the physic condition of the marsh basins constituted the principal factors limiting plant growt Propagation procedures are discussed.

In the period from 1949 to 1960, over a thousand small impoun ments were created in New York State for wildlife, particularly waterfow However, many of the wildlife marshes were not so successful as duc marshes as had been hoped. A high proportion of the unsuccessf marshes was built on the Allegheny Plateau in the Southern Tier regio On these sites there was not only a dearth of aquatic plants considere important for waterfowl food and cover, but also a lack of vegetatio in general.

The arrival of aquatic plants at a newly created aquatic habitat largely a chance phenomenon, dependent upon such natural dispersi agencies as wind and waterfowl (Ridley, 1930). Natural means of di persal often are amazingly efficient; some new water areas acquire a abundance of species in a surprisingly short span of time. On the oth hand, less auspiciously located sites may be slow to gain species of aquati (Reid, 1894). Isolated marshes in hilly topography off the regular lan of travel of waterfowl have less opportunity to receive aquatic plants tha marshes frequently visited by water birds. Thus, purposeful, artificia planting may hasten the development of aquatic plant populations i certain marshes. The artificial propagation of aquatics also may ser to (1) establish species which do not occur locally and (2) encourag food and cover plants to grow where less desirable species might otherwi thrive.

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The objectives of this study were (1) to make experimental plantings f selected aquatic plants of known or potential value as food and cover or waterfowl, and (2) to investigate factors that may limit the establishment and permanence of these plants.

PROCEDURE

Information about the requirements of most aquatic plants was ither general or lacking. Further, little was known about the complex of hysical, chemical, and biological conditions in the marshes. Therefore, veral species of aquatic plants were selected for propagation experiments be conducted concurrently with the investigation of conditions in the arshes. Propagation studies logically should be made after the requirements of the plants and the conditions in their proposed habitats are

ABLE 1. MARSHES STUDIED AND PRINCIPAL SPECIES PLANTED IN EACH

Marsh	County	Township	Species *			
			Wild rice	Hard-stem bulrush	Flowering rush	Three-square bulrush
rove	Schuyler	Hector	1	..	..	..
ornell #2	Tompkins	Lansing	..	2	2	2
ornell #4	Tompkins	Lansing	2	3	1	..
ornell #5	Tompkins	Dryden	3	5	1	1
ornell Fenced	Tompkins	Dryden	..	2	..	1
dams	Tompkins	Dryden	3	1	1	1
oom	Tompkins	Dryden	2	1	1	1
ck	Tompkins	Dryden	1	1	1	..
rbridge	Tompkins	Dryden	1	1	1	..
roton	Tompkins	Groton	1	3	1	1
anson Bear	Tompkins	Ithaca	1	2	1	..
anson Catfish	Tompkins	Ithaca	2	2	1	..
onnecticut Hill #2	Tompkins	Newfield	..	2	..	1
onnecticut Hill #3	Tompkins	Newfield	1	1	1	1
onnecticut Hill #8	Tompkins	Newfield	2	..	..	..
onnecticut Hill #11	Tompkins	Newfield	1	..	..	..
artwood	Tompkins	Danby	2	..	1	..
F. A.	Tioga	Spencer	1	1	1	1
tton #1	Tioga	Spencer	1	1	1	..
tton #2	Tioga	Spencer	2	1	1	..
st	Tioga	Tioga	1	1	1	..
rn	Tioga	Tioga	2	2	1	1
rgill	Tioga	Owego	2	1	1	..
gns	Tioga	Candor	2	1	1	.
humacher	Tioga	Candor	1	..	..	.
wan	Tioga	Candor	..	1	..	..
cken	Tioga	Barton	1	1	..	1
ylor	Madison	Cazenovia	..	1	1	..
andy	Madison	Cazenovia	..	1	..	..
lan	Madison	Cazenovia	..	..	1	..
anna	Madison	Nelson	..	1	..	..
isler	Madison	Eaton	..	1	1	..

* Number of plantings of each.

known. However, the procedure followed in this study was necessary to give the plants time to succeed or fail while the conditions in the marshes were being studied.

Planting Sites

Thirty-two marsh sites, 1 located in Schuyler County, 16 in Tompkins County, 10 in Tioga County, and 5 in Madison County, were selected for the introduction of aquatics suitable for waterfowl food and cover. The marshes are identified here by the names of the cooperators on whose land they occurred or, in the case of public ownership, by their location. The names and locations of the marshes and the principal species planted in each are given in Table 1.

Species Propagated and Their Sources

Ten species of aquatic plants were obtained from areas where they were growing naturally or from a commercial aquatic plant nursery in Wisconsin.

1. Wild rice (*Zizania aquatica*) was purchased from the commercial nursery.
2. Hard-stem bulrush (*Scirpus acutus*) was obtained from a large natural marsh (Spencer Marsh) in Tioga County (N. Y.) and from the nursery.
3. Flowering rush (*Butomus umbellatus*) was obtained from the western shore of Lake Champlain.
4. Three-square bulrush (*Scirpus americanus*) was obtained from a natural stand in Montezuma Marsh in Onondaga County (N. Y.).
5. A few plantings of American burreed (*Sparganium americanum*), arrowhead (*Sagittaria rigida*), water smartweed (*Polygonum amphibium*), marsh smartweed (*Polygonum coccineum*) and soft-stem bulrush (*Scirpus validus*) were made by transplanting stock into the study sites from artificial marshes nearby. River bulrush (*Scirpus fluviatilis*), obtained from the nursery as a result of a shipping error, was planted in one marsh.

Planting Techniques

Plantings of wild rice and a few of the hard-stem bulrush and flowering rush plantings were made by hand-broadcasting the "seeds" of these species into shallow water. Hard-stem bulrush, three-square bulrush, river bulrush, and flowering rush were propagated by rhizomes. The

maining species were introduced by transplanting entire plants. Details the propagation procedures are presented later in the discussion of ch species.

Exclosures constructed of iron fence posts and chicken wire were aced around a portion of the plantings in most of the marshes to permit aluation of muskrat damage.

Valuation of Planting Succeess

The experimental plantings were visited throughout the growing asons of 1958, 1959, and 1960. The following rating system was used describe the success of the plantings:

Good—indicated that the plants were at least surviving in the original numbers planted or were spreading, and that the individual plants were healthy and vigorous.

Fair— indicated that the plants had decreased in number from that of the original planting or the previous year. Vigor was often poorer than that of a "good" planting.

Poor— indicated that the species was still extant in the marsh, but in greatly reduced numbers from the original planting or the previous year. Vigor was usually poor, and the plants were often sterile and stunted, or suffering from the heavy depredations of muskrats.

None—indicated that the introduced plants had either failed to grow at all, or had completely died out after living for a time. In a few cases, a lone surviving individual was found.

PROPAGATION STUDIES

Details of propagation procedure, observations of the success of the antings, and a discussion of the results are presented for each species anted. The condition of 125 plantings made in 32 wildlife marshes uring the period 1955–1960 and examined in the summer of 1960 is corded in Table 2.

ild Rice

Seeds of wild rice, which is an annual aquatic grass, were planted April of 1957, 1958 and 1960, and in October 1957, by hand-broadsting into shallow water up to 3 feet deep at a rate of 1 bushel (25 unds) of rice seed per surface acre of water as recommended by Moyle

Table 2. Results of 125 Plantings Made in 32 Wildlife Marshes During Period 1955–1960

Species	Condition in summer of 1960				Numbe plant
	Good	Fair	Poor	None	
Wild rice	7	3	6	20	36
Hard-stem bulrush	3	2	3	32	40
Flowering rush	2	1	5	15	23
Three-square bulrush	0	2	1	9	12
Soft-stem bulrush	1	0	0	0	1
River bulrush	0	1	0	0	1
American burreed	1	0	0	0	1
Arrowhead	1	0	0	0	1
Marsh smartweed	1	0	1	2	4
Water smartweed	2	0	2	2	6
Total	18	9	18	80	125
Per cent	14.4	7.2	14.4	64.0	100

(1944). The 32 plantings made in 22 marshes in 1957 and 1958 w rated as follows during the summers of 1958, 1959 and 1960:

	Good	Fair	Poor	None
1958	3	5	14	10
1959	4	3	7	18
1960	6	3	4	19

Of four additional plantings made in the spring of 1960, one was ra good, two poor, and one none. Thus, of 36 plantings in 23 mar examined in the summer of 1960, 19 per cent were rated good, 8 per c fair, 17 per cent poor, and 56 per cent none.

In most instances where a stand was rated poor or none, no impr ment was noted the following year. However, a planting in the E marsh received a good rating in 1960 after receiving poor ratings the previous years. Dense submergent growth (principally *Anacharis c densis*) and the activities of cattle in the marsh inhibited the establishm of a good stand of wild rice in 1958 and 1959. The cows trampled emergent zone, ate the plants, and roiled the water. In 1960 the s mergent growth was sparser and the cows were pastured elswhere. dense stand of wild rice developed. An unexplained improvement planting in the Signs marsh occurred in 1960 following poor result 1958 and 1959.

Success was closely correlated with the quality of the marsh. G erally, results were poor in the acid, hard-bottomed, hilltop mar on Connecticut Hill in Tompkins County and in Tioga County. two successful stands in the Cargill marsh in Tioga County near Ow deserve special mention. This marsh differed from the others in Ti

unty which failed to produce wild rice crops in that its floor was com-sed of a deep, soft, organic muck. Cold springs supplied part of its ter, and the total carbonate ($CaCO_3$) concentration in its water was out 40 p.p.m. Thus, three conditions cited by Moyle (*op. cit.*) as portant for successful wild rice stands in Minnesota, namely, an organic l, a total carbonate concentration of 40 p.p.m. or above, and some water culation, were met. In contrast, the other marshes of this group all d compact mineral bottoms, were principally supplied by surface noff, and had lower total alkalinities. Good stands of rice developed other marshes in the study that were supplied only by surface runoff; us, the other two factors were probably of greater importance in deter-ning the success of stands in New York marshes.

In the less acid, softer-bottomed marshes in Tompkins County, ological influences were responsible for the failures. The Adams and ck marshes had barnyards within their watersheds. The nutrient-rich chates from the barnyards promoted abundant submergent growth in th marshes, principally duckweed (*Lemna trisulca*) in the Adams marsh d waterweed (*Anacharis*) in the Beck marsh. How important the clusion of light from the bottom by these submergents was in discourag-g emergent growth is not known. However, their growth was extensive ough to make severe limitations on space. The *Anacharis* beds re-ined alive under the ice throughout the winter. Hence, they were eady dominating the marsh when the ice thawed in the spring. In the rnell #5 marsh, as the *Anacharis* beds increased in density, the wild e growth declined from good in 1958 to fair in 1959 to poor in 1960. pronounced decrease in the density of the desirable pondweed *Pota-geton foliosus* accompanied the decline in wild rice success.

Most of the remaining failures were attributed to muskrats which extensively on the plants. In these cases, the seeds germinated and plants grew well through the floating leaf stage. As soon as the nts were standing erectly above the water, the muskrats began to feed on the young rice shoots, cutting them off at the water level. Culms re often uprooted and piled. Usually only a few shoots—those standing moist soil near the water's edge—were left untouched. Muskrat ting of varying degrees of intensity was observed in all stands. Those rshes which succeeded in producing good stands apparently were the s with a favorable balance between muskrats and available food.

Other decimating factors affected some stands during certain years. mid-July of 1958, an unexplained removal of flash boards from the ter-control structure of one marsh caused a drop in water level of 1 foot. e rice crop died as a result. A dense blanket of the floating duckweed *olffia columbiana*) probably militated against the successful establishment rice stand in the Swartwood marsh. In 1958, a dense algal bloom in Burbridge marsh limited emergent growth there. In late August

1959, after the grains had fallen, the culms of the mature plants in t Grove and Swanson marshes were attacked by a lepidopteran lar (*Papaipema nebris*). Feeding by these larvae weakened the culms a caused them to break about 1 foot above the water line. This occurr after the plants had matured and shed their grains; however, their co value was destroyed. Large numbers of blackbirds were common observed feeding upon the unripened grains. Aphids were frequen seen feeding upon the plants. Some plants, particularly those few whi succeeded in coming up in the more acid, hard-bottomed sites, exhibit chlorosis, whitening, and scorching of the leaves suggesting nutrie deficiencies.

After the ice breaks up in April, the seed of wild rice, which h been lying dormant in the mud of the marsh bottom, germinates. T young plant grows to the surface of the water where its leaves float duri May and early June. The plant erects and grows to perhaps 6 feet height above the water's surface. It flowers in July, and the gra matures in August. The first grains fall from the plant around August 2 All have fallen by the second week in September. The plant dies in l September but remains standing for a time. Thus, wild rice provid little cover before July and no food until late August and early Septemb It serves as an attractant for concentrating waterfowl during fall migrati In late summer when family groups break up and the ducks congregate flocks on the small marshes, scores of ducks have been observed using t cover afforded by rice stands. A small rice patch can effectively conc a large number of ducks (Figure 1.).

The use of the grains as food by waterfowl has not been studied the small marshes. Counts of the grains on the fertile heads of pla

Figure 1. An excellent stand of wild rice providing abundant cover in a Schu County wildlife marsh.

om several stands revealed that 57 to 76 per cent (average 65 per cent) f the glumes contained set seed; the remaining glumes were empty. The verage number of grains per head was 26. Good stands of wild rice ontained 100 or more fertile culms per square yard. This abundance of ed was adequate to produce a luxuriant growth of plants the following rowing season.

Wild rice offers several distinct advantages as a planting material r small marshes in New York: (1) it is easily propagated by hand-roadcasting the seed, (2) it provides abundant cover, at least for two r three months in late summer and early fall, (3) it supplies potential od for migrating waterfowl, (4) it flourishes in marshes which satisfy e requirements of a soft bottom and moderately acid to neutral soil nd water conditions, and (5) it thrives in water which is too deep for her emergents commonly found in the wildlife marshes. Thus, it does ot compete with the naturally occurring emergent vegetation, but instead ncreases the cover on the marshes.

ard-stem Bulrush

Hard-stem bulrush seeds were introduced by broadcasting into water p to 3 feet deep. Rhizomes were planted in the bottom with a long-andled, round-nosed shovel. The size of introduction varied from a few ctions in 1955 and 1956 to several hundred rhizomes per marsh in 1958 nd 1959. Rhizomes were planted in moist soil and in water up to 3½ et deep, 4 to 5 inches into the bottom. The hardness of the bottom ften limited the depth to which rhizomes could be placed in it.

Hard-stem bulrush plantings were made in the spring, fall, and roughout the growing season. Rhizomes obtained from Spencer Marsh were intimately enmeshed in the organic substrate underlying the oots of the bulrushes. Sections 8 to 10 inches square and 6 to 8 inches hick were the smallest which could be conveniently removed with a hovel. Each of these sections contained rhizome fragments probably elonging to a single plant.

When the bulrushes were removed during the growing season, the erial portions of the plants were usually broken in the process; so the ulms were cut away and only the rhizomes harvested. To avoid further njury to the rhizomes, the sections were planted without any attempt at eparating the individual rhizome fragments from each other or from the oil which surrounded them. For this reason certain other emergents (*Phragmites*, *Dulichium*, *Eleocharis*) associated with the bulrushes were troduced with them into the planting sites. Rhizomes purchased from he nursery had been cleaned and cut into small sections by the supplier. orty hard-stem bulrush plantings were made in 26 wildlife marshes uring the period 1955–1959. Conditions on the 22 plantings, four of

which were by seeding, made between 1955 and 1957 and observed in the summer of 1958, were: 1 good, 2 fair, 3 poor, and 16 none. Conditions on these and 18 additional plantings made in 1958 and 1959 were as follows in the summers of 1959 and 1960.

	Good	Fair	Poor	None
1959	4	0	6	30
1960	3	2	3	32

All introductions by seeding failed.

All of the rhizome introductions made in the summer of 1958 failed, even in the control plots on Cornell #5 marsh where previous transplants had been successful. Similar introductions in the fall of 1958 after growth had ceased, while nonetheless rated "poor", produced plants in three instances. This suggests that the shock of transplanting during the growing season may have been a cause of the poor results. Oborn (1951) studied translocation of carbohydrate root reserves in cattails (*Typha*) and reported that the carbohydrate levels in cattail roots are lowest at the time when flowers and fruits are being produced. The food reserves of the bulrush rhizomes transplanted during the growing season may have been depleted to the extent that new growth was not possible the following year.

The growing medium is also suspect. The source of the local planting stock, Spencer Marsh, was the only marsh in the area known to the writer, which supported a large, thriving population of this bulrush. It is a large, shallow-water marsh whose floor is composed of a rich, organic muck of the type drained in this State to raise celery, onion, and cauliflower crops.

None of the wildlife marshes studied had a substrate composition similar to that of Spencer Marsh. In the Connecticut Hill marshes and some of those in Tioga County, the topsoil was completely absent from the marsh basin. In these instances the floor was comprised of the hard fragipan horizon of the soil profile or even the "C" horizon, the so-called soil parent material horizon (Lyon *et al.*, 1952). Indeed, these impervious bottoms are the reason that the impoundments hold water, and made possible their construction.

Hard-stem bulrush tolerates a number of kinds and qualities of soils (Martin and Uhler, 1939). It grows in both salt- and fresh-water marshes on the west coast of the United States (Mason, 1957). Martin and Uhler (*op. cit.*) described it as an excellent pioneer plant in hard-bottomed lakes and it was listed as growing well "on sandy bottoms where few other plants can thrive" in a publication of the More Game Birds in America Foundation (undated).

Examination of the habitat notes on the herbarium sheets of the Wiegand Herbarium of Cornell University yielded the following environ-

nental descriptions for naturally occurring hard-stem bulrush specimens collected in central New York: "in muck", "sandy shore", "on sand bar", "sand-bottomed marsh", "gravelly reef", "open alluvial marshy flats", "sandy gravelly bar", "muddy bottom", "marly moor". The small, man-made marshes in which plantings of this species were made contain a high percentage of clay, a substrate with which hard-stem bulrush is apparently not associated at least in this area of the State. This bulrush is predominantly an inhabitant of the shores of lakes and large ponds in New York, and not of bodies of water as small as the wildlife marshes. The evidence suggests that the wildlife marshes, most of which are less than 10 years old, have not yet progressed to a stage in their development which is suitable for this bulrush. Time will be required for development of the substrate.

An attempt was made to compare locally harvested stock with that from the nursery in Wisconsin. In late April 1959, equal lots of hard-stem bulrush rhizomes were set out in adjoining plots in the Cornell #5 marsh. Both groups of plants grew well, although neither flowered in 1959. In the summer of 1960, both groups flowered. However, an invasion of cattails into the plot containing the Wisconsin stock confounded the results. The locally collected stock had increased in numbers while the success of the Wisconsin stock was only fair, the number of culms decreasing from that of the previous year.

Flowering Rush

Flowering rush is a perennial marsh herb of the monocotyledonous family Butomaceae. It is native to Europe, but naturalized populations have been present in New York at least since 1929 (Knowlton, 1930). Martin and Uhler (*op. cit.*) reported the slender corms of flowering rush in the stomach of a single green-winged teal taken in October 1935 in the region of Lake Champlain. The value of flowering rush as a waterfowl food plant has not been established.

Twenty flowering rush plantings were made in 20 Tompkins, Tioga and Madison County marshes in October-November 1956. Four of these were introduced as seeds, the remainder as root-stocks. Seeds were hand-broadcast into shallow water. Root-stocks were planted with a shovel in moist soil and in water up to 3 feet deep. The results of these plantings as observed during the growing seasons of 1958, 1959, and 1960 were:

	Good	Fair	Poor	None
1958	2	1	7	10
1959	1	3	1	15
1960	2	1	5	12

The ratings of two introductions, one by seed and the other by rhizomes, planted in the Cornell #2 marsh in September 1955 were poor in

1958 and none in 1959 and 1960. An introduction of entire plants, mad in the Groton marsh in the summer of 1958, continued to flower an produced seeds during that same growing season; it was again rated goo in 1959, but was completely unsuccessful in the summer of 1960 for reason unknown.

The plants introduced as seed in 1956 persisted for a while in 1958 but their vigor was poor, and they soon died out. Introductions b rhizomes were largely unsuccessful. Good results were obtained in th plots in the Swanson Bear Pond and in the Cornell #5 marsh. The succe of the planting in the latter demonstrated the capacity of this species t spread where soil and water conditions are favorable. From sma plantings made near the dike in 1956, this plant had in 3 years sprea over the entire 11-acre marsh.

The greater success of the plantings in the Beck marsh in 1959 an 1960 was accompanied by a decrease in the activities of cows in th marsh. The flowering rush planting in Cornell #4 marsh was rated a good in 1958 and none in 1959. Severe competition from naturally oc curring *Sparganium americanum* complicated by a complete drawdown i this marsh in connection with an engineering project no doubt wa important in bringing about the failure. The plants started to grow agai in the summer of 1960, apparently from the old rootstocks, but with on poor results.

Slight damage by muskrats was observed in most of the plantings, bu the poor results must be attributed to undetermined factors of the physic and chemical environment.

With respect to the three species discussed so far, the writer is con vinced that the numbers of plants introduced and the variety of mars habitats tried were sufficient to give results indicative of the success on might expect from plantings of these species in the areas studied.

Less extensive propagation experiments were conducted using severa other species of valuable waterfowl food and cover plants.

Three-square Bulrush

Rhizomes of three-square bulrush were collected, from a natura marsh where they were growing on moist soil, in the fall of 1958 afte growth had ceased for the season. They were planted in the moist so at the peripheries of 11 wildlife marshes in Tompkins and Tioga Counties The results of 12 introductions observed in the summers of 1959 and 196 were:

	Good	Fair	Poor	None
1959	0	1	1	10
1960	0	2	1	9

The best results were obtained in the plots in Cornell #5 marsh whe vigor was excellent, but fewer than the original number of plants intr

uced thrived. The other fair rating applied to the planting in the ecken marsh. Here vigor was poor, but a large number of the plants ntroduced survived. Examination of notes accompanying herbarium naterial collected in central New York indicated a marked preference of nis species for coarser soils, chiefly sandy soils, and to a lesser extent ravelly soils. This suggests that the physical condition of the basins of ne wildlife marshes may have been unsuitable for this species.

oft-stem Bulrush

Entire plants of soft-stem bulrush were transplanted from an artificial narsh nearby into the Becken marsh. Two large clumps comprising bout 200 individual culms were planted 6 inches deep in soil covered by foot of water. Wind and wave action was so severe that it was necessary o place flat stones over the freshly disturbed soil around the bases of the lants to hold them in place until adequate root contact could be estab- shed.

The introduction was made in August 1958, and the plants continued o develop and produce seed in their new site. The colony spread slightly n the summer of 1959, and vigor was excellent. Further spreading took lace in 1960 despite cutting by muskrats. Some breakage of culms ccurred as a result of wind.

This species occurs naturally in this region in sheltered water areas n sparsely distributed clumps offering little cover. The culms are weak nd bend and break easily; thus it would be difficult to establish in the xposed marshes which predominate in the region. Therefore, further ntroductions of this species were not attempted.

iver Bulrush

About 500 river bulrush rhizomes were planted in moist soil and in ater 1 to 6 inches deep in the Swanson Catfish Pond in May 1959. lants developed, but they were stunted, chlorotic, and sterile in 1959. lowever, vigor was excellent in 1960, and 59 culms developed. The lants did not flower. This species fruits erratically and propagates hiefly by vegetative reproduction. Because of the paucity of seeds pro- uced and the severe competition with better duck foods which the rank rowths of natural populations of river bulrush provide, Martin and Uhler *op. cit.*) advised that it not be encouraged.

merican Burreed

Entire plants of American burreed were introduced from a marsh earby into the Becken marsh. They were planted in water 1 to 6 inches eep. This was accomplished in late July 1958, and the plants continued

to develop and produce seeds the same summer. The plants continued to spread in the summers of 1959 and 1960. Vigor was excellent, and fruits were produced. Muskrat cutting was insignificant.

Arrowhead

Four hundred plants of arrowhead were transplanted from the Cornell #5 marsh into the Becken marsh in early August 1958. This species was planted in water 1 to 6 inches deep. The aerial portions of the entire crop were destroyed by muskrats in the spring of 1959 shortly after they had grown to the surface of the water. The colony quadrupled in size during the growing season of 1960. Although muskrat cutting was very heavy, the plant growth succeeded in staying ahead of the depredations of these animals.

Smartweeds

Entire plants of marsh smartweed were introduced into four Madison County marshes in the fall of 1956. One planting was rated good, one poor, and two none in 1960.

Entire plants of water smartweed were transplanted from the Zorn wildlife marsh to three Connecticut Hill marshes and three marshes in Tioga County in the late summer of 1958. Two were rated good, two poor, and two none in 1960.

Although all of the smartweed plants which developed flowered profusely, none produced seeds. Martin and Uhler (*op. cit.*) reported that shallow water favors abundant fruit production in these species, but that plants which are continuously inundated for more than two years decline in abundance and in seed production. The smartweed plantings in the wildlife marshes were continuously flooded, some by water 3 to 4 feet deep, and this may explain their failure to produce seeds. The plants growing naturally in the Zorn marsh were in 5 to 6 feet of water and had not produced seed despite an abundance of flowers.

DISCUSSION

Planting should be done only after careful study shows that the species proposed for introduction is absent from the marsh and can reasonably be expected to thrive in its new environment. Plantings in areas where stands of well established, naturally occurring species already predominate are inadvisable. On the other hand, a paucity of natural vegetation may be an indication that conditions of the habitat must change before abundant plant growth is possible; hence, artificial propagation is not the solution in such instances.

Plant propagating materials can be obtained from commercial aquatic plant nurseries, or they can be collected locally from areas where they grow naturally. Collecting local materials is cheaper in some cases. Theoretically such materials have a better chance for survival than plants obtained from other geographical areas. Part of the explanation for this lies in the fact that a given plant species may be represented by a number of geographical, physiological, or ecological races which differ in their requirements and tolerances. The probability of failure is even further increased when species, genera, and families which are foreign to the local flora are considered for introduction. The use of local materials diminishes the possibility that the stock will be unsuited to its new habitat.

The ideal planting material is that collected locally and planted with a minimum of labor, i.e., by broadcasting. Transplanting rhizomes and other underground reproductive structures is a laborious and time-consuming task. However, the rhizomes of aquatic perennials are generally preferable to the fruits as propagating material since the fruits often germinate erratically.

Fall is recommended for harvesting and planting underground reproductive structures of perennial aquatics. At this time the water is shallower and warmer than in spring, and personnel employed on the job can be expected to do more careful work. Fall planting also eliminates the problems attending winter storage of the propagating materials. On the other hand, materials propagated in spring are less likely to be destroyed by waterfowl or damaged during adverse weather. In spring, marsh waters are usually swollen by runoff. At this time care should be taken to plant aquatics where standing water will be available throughout the growing season. The remains of the previous year's wetland species, such as *Juncus effusus* and *Carex* spp., are useful in locating the normal water level of a marsh. These species commonly grow on the moist soil at the water's edge. The normal water level can also be marked in the fall with stakes of sufficient length to show above the surface of the water in spring.

Further propagation studies of the results of transplanting local species of aquatics which occur naturally in wildlife marshes to marshes where they are lacking would be desirable. The limited number of instances in which this was tried in this study gave encouraging results.

CONCLUSIONS

Artificial propagation of aquatic plants in marshes created on shallow, depauperate soils in hilly topography should be considered only as a subsidiary management measure to be attempted only after the basic defects of the habitat have been corrected. Planting cannot remedy errors in site selection and design. Muskrat control may be necessary while stands are becoming established.

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HEPATOMA AND VISCERAL GRANULOMA IN TROUTS

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ABSTRACT

All vertebrates are subject to numerous neoplastic diseases. In some instances the incidence of neoplastic diseases is very high as in the case of hepatoma in hatchery-raised rainbow trout. In hatchery-raised brook trout a visceral granuloma seems to be equally frequent. At the present time one can only speculate on the causes of these diseases, but circumstantial evidence seems to incriminate genetic makeup nutrition, and metabolism as the most likely contributing factors in both diseases.

Fishes, as all other vertebrates, are subject to neoplastic diseases (Schlumberger and Lucké, 1948; Nigrelli, 1954). Until recently the incidence of neoplasms in fishes was apparently so low that they were only of scientific interest. Occasionally there were some large-scale outbreaks of tumors in trout, for example the thyroid carcinoma (Gaylord and Marsh, 1914) and neurilemmoma (Young and Olafson, 1944).

Hepatoma in rainbow trout was reported on several occasions. In some cases the incidence was fairly high (Rucker *et al.*, 1961). Since many of the examined rainbow trout of both sexes with large hepatomas were 4 to 5 years old, it seems that the mortality rate caused by this disease may be low. Fishes are seldom examined by fish pathologists unless losses occur which is probably the reason why there were few reported cases of hepatoma until surveys on regional and national scales were carried out during the summer and fall of 1960. These surveys were made in all federal and some state trout hatcheries. The surveys indicated that hepatoma was present in many but not all hatcheries, and that the incidence of the disease was about the same throughout the United States. While in some instances hepatoma was present in trout less than one year old, it was found more frequently and in more advanced stages in adult fish. To my knowledge rainbow trout were not examined for the presence of hepatoma, or brook trout for the presence of visceral granuloma, under wild conditions. It seems unlikely that diseased trout would have a fair chance of survival under competition prevailing in nature.

While hepatoma is common in hatchery rainbow trout, hatchery brook trout have a high incidence of so called *mycosis-like* granuloma (Wood *et al.*, 1955). It is believed on the basis of unpublished investigations that the term *visceral granuloma* is more appropriate for this disease. It seems probable that the neurilemmoma described by Young and Olafson (1944) was of the same nature.

Considerable publicity given to the liver cancer condition of rainbow trout has not always presented the facts that the condition has not been found in other species of trout, in rainbow trout it is confined to older

individuals under hatchery conditions, it is not known to be transmissibl from one trout to another (with the possible exception of parent to fr via egg, as discussed later) and it is not known to be transmissible fro trout to other organisms or to humans. A number of letters to the Ne York State Conservation Department and to other agencies have indicate considerable alarm on the part of sportsmen. It is considered importan to take all precautions, insofar as known, to prevent the condition and number of suggestions to this end are included in this paper.

Neoplasms and granulomas can be diagnosed with accuracy b histopathological examination and only a tentative diagnosis can be mad by gross examination. In advanced cases the tumors can be so larg that the body may be bulging in the area of the liver and stomach, bu in all cases it is necessary to perform histopathological examinations fo establishment of the presence of tumors in fishes. In hepatoma th lesion may be visible to an unaided eye as small white nodules up t large cysts filled with fluid. The liver may be very enlarged and change in appearance (Rucker *et al.*, 1961).

Visceral granuloma most frequently affects the stomach, pylori caeca, and kidney. In early stages the only change in affected organ visible to unaided eye are very small white nodules, but in advance cases the affected organs may be enlarged many times. In the kidne the nodules are similar to those seen in kidney disease, except that the are hard instead of cheesy consistency and bacteria cannot be found However, the presence of granuloma and kidney disease in the sam trout is not uncommon. There seems to be no relationship between thes two diseases.

It must be restated here that gross examination should never b relied upon for firm diagnosis. Histopathological examination is th only accepted procedure for reliable recognition of a neoplasm or granuloma.

At the present time no definite statement can be made about the causes of hepatoma or visceral granuloma in trout. Even in cases o human cancer the etiology of the disease is either poorly known or entirel obscure. Research on neoplasms have revealed that many factors ca contribute to the occurrence of neoplasms or granulomas such as variou chemicals, malnutrition, overfeeding, infection, physical agents, etc. Recently, stress due to crowding has been shown to contribute to the inci dence of granuloma in mice (Christian and Williamson, 1958). One has to remember that genetical factors are also very important in that strain of animals resistant to certain tumors will not develop tumors or ma have a reduced incidence of them, even if exposed to carcinogenic agents. In susceptible animals some types of neoplasms and granulomas ar caused by viruses, bacteria, or parasites. Therefore, in each case o

nusually high incidence of any type of tumor, attempts should be made o determine, if possible, the specific cause.

Nutritional factors or the presence of possible carcinogenic agents n food have been implicated in the recent outbreaks of hepatoma in ainbow trout. So far the evidence is only circumstantial and premature onclusions should not be drawn until well designed and carefully evaluated experiments are performed.

The existence of infective agents has not been established in regard o hepatoma in rainbow trout and visceral granuloma in brook trout; herefore, nothing is known about the source or reservoir of these diseases.

Rainbow trout seem to be very susceptible to hepatoma (Nigrelli and kowska, 1961). This may be due to the fact that this species seems to be ffected by metabolic diseases such as lipoid degeneration of the liver Davis, 1953), liver and kidney syndrome (Schäperclaus, 1954), anemia Besse, 1956), and disturbances in fat metabolism (Faktorovitsch, 1960). enetical factors are also strongly implicated by European investigators Cudkowicz and Scolari, 1955). Brook trout seem to be particularly sceptible to the visceral granuloma.

Hepatoma in rainbow trout has been reported from the United States Rucker *et al.*, 1961), Europe (Cudkowicz and Scolari, 1955), and Asia Honma and Shirai, 1959). So far brook trout granuloma has been seen nly in the United States.

Occurrence of hepatoma of rainbow trout is very high in affected opulations. Occurrence of visceral granulomas of brook trout in ffected lots was from 5 to 50 per cent.

No reliable methods of control can be recommended until the causes f these diseases are known. It is suspected that some, so far unknown, arcinogenic agents may be involved. Such agents may be present in any omponent of the food or originate in food during processing or storage, r may be present in additives. Therefore, caution should be used when electing feeds of unknown composition which were not tested thoroughly n feeding trials of sufficient duration.

Since infective agents may also be involved, trouts free from tumors hould not be kept in a water supply in which diseased fish are present. Transmission of ineffective agents is possible through eggs, and, since ereditary susceptibility may play an important role in the incidence f fish tumors, eggs should be procurred whenever possible from hatcheries ree from recent occurrences of neoplastic diseases or granulomas.

Since overfeeding is known to cause metabolic diseases, which may esult in tumors, forced growing of trout by overfeeding should be avoided.

The manufacturers of prepared fish feeds should be alerted to the ell established cases in which machinery was contaminated with different dditives (drugs, hormones, antibiotics) and such additives accidentally ontaminated batches of feed for which they were not intended. In some

cases unpleasant results occurred. In other cases batches of feed were contaminated with machinery lubricants containing strong carcinogens. Some raw materials, as fish meal for example, contain fats which easily undergo chemical changes and in this way may become carcinogenic during processing or storage.

It is customary to enrich feeds with different drugs which, if used for prolonged periods of time, even in small dosages, may have carcinogenic action. Fish feed should not contain *any* additives, the necessity of which is not indicated by thorough investigations.

There are many unknown factors which may contribute to the incidence of tumor in fishes. The most promising approach seems to be through research on the nature of hepatoma and visceral granuloma as well as on other neoplastic and metabolic diseases of fishes.

ADDENDUM

This information is given in an addendum since its bearing on the problem of hepatoma and visceral granuloma in trout is purely speculative.

During the past decade rainbow trout in Europe and the United States suffered severe outbreaks of a disease which Schäperclaus (1954) called "swelling of the kidney and degeneration of the liver" and the French author Besse (1956) called "infectious anemia". It seems that it is an ailment similar, or identical with, the "lipoid degeneration of the liver" (Davis, 1953).

According to German authors this disease is caused by a virus, the size of which has been determined already. German and French authors reported that the severity of the disease can be well controlled by nutrition or to a degree by antibiotics.

Besse *et al.* (1960) and Levaditi *et al.* (1960) found hepatoma to be present in France in populations of adult hatchery-raised rainbow trout. Experiments on the transmission of this disease failed. They described its symptoms and histopathology.

Ghittino (1961) described lipid degeneration of the liver in rainbow trout and included photographs suggesting that this probably was a case of hepatoma. Transmission of the disease was tried but without success. He listed improper foods and overfeeding as probable causes of the disease.

Wood and Larson (1961) described the outbreak of this disease which occurred in the western United States in 1960, including its pathology and histopathology. He noted that nutritional factors and the presence of carcinogens in food are suspected as the most likely causes of this outbreak and discussed other possible causes.

There seems to be some coincidence in time between the increased severity and frequency of this disease in Europe and the United States with the change from "wet" to "dehydrated" trout diets. It is known that some types of neoplasms and most of the granulomas are caused by

ıfective agents. Therefore, when investigating this problem, one should ɔep in mind that hypothetically there may be a causal relationship ɔetween "infectious swelling of the kidney and degeneration of the liver", ıanging of feeding practices, incidence of hepatoma, and granuloma ı trout.

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GENERAL NOTES

A HOLDING PEN FOR VARYING HARES

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Large-scale plantings of conifers have been made during the past 25 years throughout New York State as Christmas tree plantations, reforestation of abandoned farmlands, and more recently as wildlife habitat restoration under Federal Aid Project W-48-D. In many localities, suitable varying hare habitat has been created, but there has been no source from which these animals could be expected to spread into it within a reasonable time. In such situations, populations have been established by trapping and transferring wild hares from areas affording a surplus.

Trapping for such purposes is done during the winter, and the vagaries of weather impose frequent limitations. Not only do they affect trapping success itself, but poor success together with transportation difficulties to and from the area being trapped often make it necessary to hold hares for several days before the quota for a shipment can be filled. Hares confined in shipping crates for more than 3 days exhibit some loss of vigor upon release, and holding them for 5 days has resulted in mortality.

In an effort to meet this problem, a holding pen was built in 1959 at the DeBar Mountain Game Management Area (Franklin County) where trapping operations were being carried on. It was located in a protected bay in a 30-year-old pine plantation and consisted of three 40 x 50-foot contiguous units. Cedar posts were set in place prior to freezeup, and 2-inch-mesh poultry wire 6 feet wide was used for the sides and partitions the lower edges of which were embedded 6 inches in the soil. Each unit contained one large pine, incidental small spruce and balsam undergrowth, and blueberry groundcover.

The pen was put into operation on January 15, 1960 and 15 newly trapped ares were placed in one unit. Numerous Norway spruce boughs were stacked for dditional cover, and aspen saplings were cut and supplied for food. It was soon ound that the nuisance of cutting fresh browse and removing the old, plus the attendant arassment of the hares, could be eliminated by feeding commercial rabbit pellets. lso, snow accumulated to an extent that required an additional 2 feet of fencing to revent escape. When hares were later put in the second unit, spruce and pine boughs ere set butts down, three or four together, to form small teepees. The hares readily ccepted such shelter and the commercial food pellets from weather-proof troughs.

The first lot of 15 hares were held a week for observation of behavior and con- ition. Then 20 hares were placed in the second unit of the pen. By this time those the first unit were noticeably quieter and better adjusted than the new arrivals. hey did, however, continue to "fight" the wire because of lessening shelter as the snow eepened and became more impacted. Before hares were placed in the third unit, atted wooden snow fencing was fastened to the inside of the poultry wire. This educed the possibility of eye injury from the wire and increased the protective cover. now fencing was later installed in the other units and would be desirable even though -inch-mesh wire were used.

By the end of the winter of 1960 the hares had so chewed the wooden snow fence hat some entanglement occurred between it and the outside poultry wire. Therefore, 1961 a facing of 1 x 2-inch-mesh electric-welded fencing was installed inside the snow nce. Any additional pens will be constructed of such electric-welded fencing 4 feet igh surmounted by 4 feet of 1-inch-mesh poultry wire. The snow fence outside this an be either permanent or seasonal as desired. Gates or doors should be 1½ feet bove the ground to facilitate use throughout the winter without excessive chopping impacted snow. A small snow blower can be effectively used to clear pens before nd between use periods.

From the experience of two seasons, a maximum of 20 hares per unit can be uccessfully held in a pen of this sort through mid-February. After that time, fighting educed by the mating season can be expected. However, hares in a ratio of about 0 per cent females to 40 per cent males were held without trouble from March 7 to 7, 1961. While no visible injuries from fighting were evident, this was probably due adequate evergreen bough shelters.

Hares were seldom held more than 2 weeks before being shipped. In catching the nned hares for shipment, it was found that box trapping entailed less harassment an using a net.

Although the possibilities for predation were great, none occurred during the two ars of operation even though coyotes ranged within 150 yards of the pen and fisher acks were found within ¼ mile. Weasels frequented the field and building area arby. No evidence of owls was noted.

FEEDING DYES TO CARP[1]

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During the past three decades attempts have been made to color fish and other nimals for various reasons and with limited success. Lack of success has probably en the result of relatively meager effort. Thousands of dyes are available, but few ve been tested. Thus, there is no reason to believe that fish could not be perman- tly marked if dipped in, fed, or injected with certain dyes. Experiments with loration by injection and dipping have been made by several workers and at the sh Laboratory at Livingston Manor (N. Y.). Dipping in several water-soluble dyes ch as Rhodamine B, Bismark brown, and neutral red has produced coloration sting for several days in adult carp. Injection of numerous substances has produced arks which have lasted for weeks or months, and one dye, Pontamine Fast Pink Dupont), has produced local pink marks which have remained for over a year after st turning the entire fish a bright pink. The work reported here involved feeding

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R.

dyes to fish in attempts to increase consumption of food and to cause coloration trout and carp.

Certain species of fish appear to prefer foods which are red in color. This h been demonstrated for trout by various workers. F D & C Amaranth #2, a wate soluble certified dye, was used by Wolf (1953) to dye fish pellets red. Wolf conclud that the red pellets were picked off the bottom, while ordinary tan baits or tho colored green, blue or yellow were often ignored. Red pellets have been used for number of years in trout hatcheries with varying reported degrees of success. Bro trout in this laboratory definitely appear to be attracted strongly toward the colo red and yellow. Adult carp show no apparent color preference under laboratory co ditions, but fingerlings do. Bright colors are favored, red especially. The use certified food colors for increasing pellet consumption is preferable because they a inexpensive, harmless and tasteless. They also hold in doughy foods until the foo decay despite the fact that most are water-soluble.

Food dyes were fed to carp in an attempt to color the epidermis of the fish for lo periods of time. The purpose was to determine the percentage of a carp populati which might eat a poison bait. Various food dyes produced no external effect but we found to be useful in another way. The percentages of carp populations which a various baits in ponds were determined by feeding water-soluble dyes. In this ca the fish were killed some hours after feeding and the intestines examined for the presen of the brightly colored feces. Red proved to be the best for this purpose when da foods were used. Yellow was suitable for light-colored foods only. Water-solub food dyes proved to be completely palatable.

Almost any palatable dye will do for staining the intestine and feces. Oth dyes fed to carp were as follows: F D & C Yellow #4, an oil-soluble food dye which w slightly unpalatable at a level of 2 per cent; F D & C Red #27, a slightly water-solub dye which was also slightly unpalatable; cadmium red and cadmium yellow, bo insoluble in water and palatable; indigotin, a blue, insoluble and palatable dye whi was unsuitable for feces staining becauses it closely resembled the dark coloration some natural foods; Sudan III, a red, oil-soluble and palatable dye fed at doses up 280 milligrams per kilogram. None of these produced any external coloration of fi

Another dye, alizarin red S, was fed to carp at a concentration of 5 per ce Although slightly soluble it was readily eaten. No external coloration was produce Alizarin is contained in madder root which was fed by Lawrence (1941) to rainb trout over a period of six weeks to produce a red color in bones.

Rhodamine B, a reddish, very soluble powder, was fed to carp in two wa Baits, each containing 2.6 milligrams of shellaced particles of dye, were ineffect because the particles were rejected although the remainder of the bait was eat The particles dissolved in a few hours, turning the tank water a bright pink.

Other baits consisting of 1 part of Rhodamine B to 9 parts of flour were shella and fed to carp. Four fish rejected the baits with shredding. One fish consum several baits and was colored a dark pink for 5 days. On the 6th day the color h lightened and on the 7th it was just distinguishable.

Single feedings of the oil-soluble dye Sudan black (Solvent Black 3, Colour Ind No. 26150) produced a blue coloration of all tissues but tooth enamel. The exter blue coloration appeared first in the mouth some 24 hours after ingestion of a sufficien high dose, and then spread to the chin and throughout the body. Carp were unaffec by the dye which, at a water temperature of 65° F., persisted for from several days months depending on the dose ingested. The dye is completely insoluble in wa and is palatable. Several case histories may be pertinent.

Seven carp were fed as many ¾-inch dyed flour baits (containing 2.7 per cen Sudan black) as they could eat. All fish became dark blue in 24 hours and the co has persisted in diminishing degrees for 60 days at this writing. Similar feeding per cent baits produced a lighter blue which has persisted for 44 days.

Carefully administered doses to individual fish, either in single meals or ove number of days, showed that 75 mg/kg are necessary for sure external colori Accumulation in and loss from the tissues was demonstrated.

Neither a single meal of 19 mg/kg, or 37 mg/kg fed over a period of 12 days, p duced external coloration. In the latter case the intestine was blue through Single meals of 39, 47, and 58 mg/kg produced coloration of the mouth at the lo dose and of both mouth and chin at the higher doses. In all three experiments color disappeared in 2 weeks or less. At higher doses the coloration was more inte extended over a greater portion of the body and also lasted for longer periods. Si seven mg/kg produced heavy coloration of the entire head for 10 days at which t the fish was killed because of heavy fungus infection. Seventy-eight and 143 mg produced intense coloration of the head and belly, the lower dose causing colora

30 days while the other fish was light blue at the end of that time. Obviously the e is either lost from or changed within the body as time goes on.

Temporary accumulation in the body was demonstrated by feeding two fish rying amounts of dye over a period of time; 37 mg/kg fed over a 3-day period pro- ced a light blue coloration of the mouth on the 4th day, and an additional 16 mg/kg that day caused a darker coloration by the 7th day. The chin had lost its color by e 9th day, but the mouth was blue until the 17th day. Fifty-three mg/kg fed to the ond fish over a period of 13 days did not cause external coloration. A total of mg/kg by the 17th day produced a blue coloration of the mouth and chin by the st day.

Although Sudan black baits containing up to 4.8 per cent of the dye were palatable carp this may not be true of some other species. The black color probably influences degree of attractiveness. Pumpkinseed sunfish would not pick up the black baits hough red baits were accepted. Most 6-inch brown trout would not accept the baits; e fish did and became blue. Single forcefeeding of large doses of baits caused a deep ue coloration of brook trout and brown trout in 6 and 4 days, respectively, at a water nperature of 47° F. Goldfish accepted the baits and became blue.

Injections of a solution of Sudan black and peanut oil into the body cavity and isculature of carp were without effect. The solution remained unchanged at the ection site until dissection after 10 days.

Use of Sudan black would, of course, be dependent to some extent on the effect on humans and other animals that might eat dyed fish. Boiling carp flesh for 10 nutes did not destroy the dye, but decomposition quickly eliminated the color operties. Sudan black was fed in unknown quantity to three white rats at a concen- tion of 1 per cent. The bait was eaten readily within a few hours, after which watery ick feces were formed. The feces were also eaten. The rats appeared to be some- iat affected by the dye, but no external tissue coloration was noted. The animals uld not eat the dye thereafter. Sudan black, which stained fat in mice according to w (1959), might not be suitable for use in fish that may be consumed by humans. is can be determined only by additional tests. Dyes which can be used probably st. Marking hatchery trout by mass production methods is a suggested use.

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